GLOSSARY

ACRE-FOOT. The quantity of water required to cover 1 acre to a depth of 1 foot. It is equal to 43,560 cubic feet or 325,851 gallons.

ADIT. A horizontal or near-horizontal passage from the ground surface into a mine or underground installation.

ADVERSE VISUAL IMPACT. Any impact on the land form, water form, or vegetation, or any introduction of a structure that negatively changes or interrupts the visual character of the landscape and disrupts the harmony of the natural elements.

AIRBLAST. A motion-producing sound generated by an explosive blast and resulting rock breakage and movement; it is commonly expressed as a relative sound level in decibels (dB) at a particular frequency that is measured in hertz (Hz). Like ground vibration, it is an undesirable side effect of the use of explosives to break rock for mining, quarrying, excavation and construction.

ALLUVIUM. Clay, silt, sand and gravel deposited by running water.

AMBIENT. Conditions in the vicinity of a reference point, usually related to physical environment (e.g., the ambient temperature is the outdoor temperature).

ANGLE OF REPOSE. The maximum slope at which a heap of any loose or fragmented solid material will stand without sliding when poured or dumped in a pile or on a slope; also called the angle of rest.

AQUIFER. A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield a significant quantity of water to wells or springs.

ATOM. A particle of matter indivisible by chemical means. It is the fundamental building block of the chemical elements. An inner core (the nucleus) is composed of protons and neutrons, while one or more much smaller electrons orbit the nucleus.

ATOMIC MASS UNIT (amu). One-twelfth the mass of an atom of carbon-12. $1 \text{ amu} = 1.66057 \times 10^{-27}$ kg.

ATOMIC NUMBER. The number of protons in the nucleus of an atom. It is shown as a subscript in atomic nomenclature. For uranium-238 ($_{92}U^{238}$) the atomic number is 92.

ATOMIC WEIGHT. The sum of the number of protons and neutrons in the nucleus of an atom. It is shown as a superscript in atomic nomenclature. For uranium-238 ($_{92}U^{238}$) the atomic weight is 238.

BACK. The rock above any opening, such as a tunnel, stope or drift; the roof.

BACKGROUND LEVEL. The concentration of a pollutant that would exist in the absence of the particular source under study. A "standard" against which the contribution of the particular source can be compared.

BACKGROUND RADIATION. The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements.

BALLAST. Rough, unscreened gravel used to form the bed of a railway or as substratum for new roads.

BASE FLOW. The sustained or normal flow of a stream.

BED. The smallest division of a stratified series of rock layers, marked by a more or less well-defined divisional plane from its neighbors above and below.

BENCH. In open-pit mines, a ledge that forms a single level of operation above which mineral or waste materials are excavated from a contiguous bank or bench face. The mineral or waste is removed in successive layers, each of which is a bench, several of which may be in operation simultaneously in different parts of and at different elevations in an open-pit mine.

BORROW PIT. Location from which soil materials are taken to be used as topsoil on reclaimed sites.

BULKHEAD. A tight partition of wood, rock or concrete in mines to contain some material.

CAVING. The action of caving in, collapsing; the failure and sloughing in of boreholes, mine workings or excavations.

CHARGE DELAY. The time separation, usually in milliseconds, between detonation of individual charges of explosives in a blast.

COEFFICIENT. In physics, a number commonly used in computation as a factor, expressing the amount of some change or effect under certain conditions such as temperature, length, time or volume.

COHESION. That property of like mineral grains that enables them to cling together in opposition to forces tending to separate them; measured in pounds per square foot.

COLLUVIUM. Loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity.

COLOR. The property of an object that reflects light of a particular wavelength, enabling the eye to differentiate otherwise unidentifiable objects.

CONSOLIDATED. In geology, having been pressed into a hard rock. In soil mechanics, having simply been brought into equilibrium with the applied forces causing a decrease in volume.

CONTOUR FURROWING. Plowing along the contour lines of uneven terrain to limit erosion.

CONTRAST. The effect of a striking difference in the form, line, color or texture of the landscape features within an area being viewed.

CONTROL. A standard of comparison in scientific experimentations; check.

COUNTRY ROCK. Rock adjacent to or surrounding a mineral deposit or dike in which no minerals of economic interest occur.

CREST. The top of an excavated slope; the highest natural projection that crowns a hill or mountain.

CROSSCUT. In underground mining, an opening driven across a deposit, or, in general, across the direction of the main workings.

CUBIC FOOT PER SECOND (ft^3/s or cfs). The rate of discharge representing a volume of 1 cubic foot of water passing a given point during 1 second. It is equivalent to 7.48 gallons per second, or 448.8 gallons per minute.

CURIE. The measurement of radioactivity of a substance. One curie equals the disintegration of 37 billion (3.7×10^{10}) nuclei per second, which is approximately the rate of decay of 1 gram of radium.

DAUGHTERS, PROGENY. Nuclides formed by the radioactive decay of other nuclides (the parents).

DECAY, RADIOACTIVE. The spontaneous emission of radiation from the nucleus a radioactive atom. This will either transform one nuclide into a different nuclide, or change the energy state of the same nuclide.

DECIBEL (dB). A unit used to express the relative intensity of sounds on a scale from 0 (for the average least perceptible sound) to about 130 (for the average pain level).

DECLINE. A shaft sunk at an angle from the vertical.

DENDRITIC. Formed or marked in a branched or tree-like pattern.

DIABASE (DIABASIC). A fine-grained intrusive rock composed mainly of plagioclase feldspar and pyroxene.

DIKE. An igneous intrusion that cuts across the planar structures of the surrounding rock (See Sill).

DIP. The angle of a slope, vein, rock stratum or borehole as measured from the horizontal plane downward.

DISCHARGE. The rate of flow at a given instant in terms of volume per unit of time (e.g., cubic feet per second or gallons per minute).

DOSE, ABSORBED. The amount of radiation absorbed; the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The special unit of absorbed dose is the rad.

DOSE COMMITMENT. The total dose that an organism is expected to receive in its lifetime from a given quantity of radioactive material deposited in the body.

DOSE EQUIVALENT. A common scale measurement of the effects of the different types of radiation. The unit of dose equivalent is the rem. The following are considered equivalent to 1 rem of dose: 1) a dose of 1 Roentgen (R) due to X- or gamma rays; 2) a dose of 1 rad due to X-, gamma or beta radiation; 3) a dose of 0.1 rad due to neutrons or high-energy protons; and 4) a dose of 0.5 rad due to particles heavier than protons (i.e., alpha radiation).

DRAWDOWN. Vertical distance the free water elevation is lowered, or the reduction of the pressure head due to the removal of free water.

DRIFT. A horizontal passage underground, with neither end reaching the surface.

ELECTRON. An elementary particle having a charge of -1 esu (electrostatic unit) and a mass of 1/1837 amu (atomic mass unit).

ENTRY. An underground passage for hauling, ventilation or as a way of transit for miners.

EPHEMERAL STREAM. A stream or portion of a stream that flows only in direct response to precipitation in the immediate locality, and whose channel is at all times above the water table.

EXPOSURE. The quotient dq/dm, where "dq" is the absolute value of the charge of the ions of one sign produced in air, when all the electrons (negatrons and positrons) liberated by photons in a volume element having mass "dm" are completely stopped by air. The special unit of exposure is the roentgen (R).

EXPOSURE RATE. The exposure per unit of time (e.g., roentgens/minute, milliroentgens/hour).

FACE. In any adit, tunnel or stope, the end at which work is progressing or was last done.

FAULT. A fracture or fracture zone along which there has been displacement of the two sides relative to one another and parallel to the fracture.

FLUVIAL. Of or pertaining to a river or rivers. Produced by the action of a stream or river.

FORM. The mass or shape of an object or objects which appear unified, such as in the shape of the land surface or patterns placed on the landscape.

FORMATION. A more or less related group of rocks grouped together into a unit that is convenient for description and mapping.

FRACTURE. Failure by the parting of a material.

FRICTION ANGLE. The angle between the perpendicular to a surface and the resultant force acting on a body resting on the surface, at which the body begins to slide.

FRICTION ANGLE (ANGLE OF INTERNAL FRICTION). The angle which characterizes the increase in sheer strength with increasing normal stress on a given plane in a material. The tangent of the angle of internal friction is the increase in shear strength for a unit increase in normal stress. It is approximately equal to the angle of repose for dry, cohesionless materials.

FUGITIVE DUST. Particulates made airborne by forces of wind, man's activities, or both.

GRADIENT. The ratio of vertical fall of a river's channel to its length.

GRANTS MINERAL BELT. Includes the area of uranium deposits from Gallup on the west to the western edge of the Rio Grande trough on the east.

GROSS ALPHA. The total rate of alpha particle emission from a sample without regard to energy distribution or source nuclide.

GROSS BETA. The total rate of beta particle emission from a sample without regard to energy distribution or source nuclide.

GROUND VIBRATION. An undesirable side effect of the use of explosives to break rock for mining, quarrying, excavation and construction; expressed as the velocity of a particular point or particle in the ground (particle velocity), and measured in inches per second (in/s).

GROUND WATER MOUNDING. The mound-shaped build-up of the potentiometric surface resulting from the downward percolation of water into an aquifer.

GROWTH MEDIUM. A soils material, natural or reconstituted, that will support a plant community.

HALF-LIFE. The time required for a radioactive element to lose half of its atoms through radioactive decay. Each radionuclide has a unique half-life.

HEAD, STATIC. The height above a standard reference point of the surface of a column of water that can be supported by the static pressure at a given point.

HEAD, TOTAL. The total head of a liquid at a given point is the sum of three components: 1) elevation head, which is equal to the elevation of the given point above a reference point; 2) pressure head, which is the height of a column of static water that can be supported by the static pressure at the given point; and 3) velocity head, which is the height the kinetic energy of the liquid is capable of lifting it.

HERTZ (Hz). A unit of frequency equal to one cycle per second.

HIGH PASS. A method of measuring airblast in decibels (dB) at a certain frequency in hertz (Hz).

HIGH-RADIATION AREA. Any area accessible to individuals in which a major portion of the body could receive, in any one hour, a dose in excess of 100 millirems.

HIGHWALL. The excavated face of exposed overburden and/or ore in an open-pit mine.

HORIZON. Layers (in a soil profile) resulting from soil-forming processes are grouped into three categories (A, B and C). The subdivisions of these categories are called horizons.

HYDRAULIC CONDUCTIVITY. The rate of flow of water in gallons per day through cross-section of 1 square foot of a subject medium under a unit hydraulic gradient. (Synonym, permeability coefficient.)

IN SITU. In its natural position or place.

INTERNAL RADIATION. Radiation from a source within the body as a result of deposition of radionuclides in body tissues by ingestion, inhalation or implantation.

INTRUSION. A feature (land and water form, vegetation or structure) that is generally considered out of context because of excessive contrast and disharmony with the characteristic landscape.

ION. An atom that carries a positive or negative electric charge as a result of having lost or gained one or more electrons.

IONIZATION. The process by which a neutral atom acquires a positive or negative charge.

ISOTOPES. Atoms with the same atomic number but different atomic weights. The difference in atomic weight is due to the number of neutrons in the atom's nucleus.

LEVEL. A horizontal passage or drift into or within a mine. It is customary to work mines by levels at regular intervals in depth.

LINE. The path, real or imagined that the eye follows when perceiving abrupt differences in form, color or texture. Within landscapes, lines may be found as ridges, skylines, structures, changes in vegetative types, or individual trees or branches.

MAJOR (STRUCTURAL) BLAST DAMAGE. The most severe type of damage to structures caused by blasting. This type of damage affects the load-supporting ability of a structure (e.g., rupture of arches, falling of masonry, structural weakening).

MINING HEIGHT. The height of an underground mine opening.

MINOR BLAST DAMAGE. An intermediate level of damage to structures caused by blasting (e.g., loosening and falling of plaster, hairline to 1/8-inch-wide cracks, falling of loose mortar).

MUCK. Broken ground from an underground mining operation.

NEUTRON. An elementary particle having no charge and a mass of 1 atomic mass unit.

ORE. A mineral of sufficient value (quality and quantity) that it may be mined with profit.

ORE ZONE. A horizon in which ore minerals are known to occur.

OVERBURDEN. Soil and rock horizons as measured from the surface down to a specific mineral layer.

OVERPRESSURE. The pressure in an airblast wave in excess of the atomopheric pressure.

PAN EVAPORATION. The amount of water that evaporates from a standard U.S. Weather Bureau 4-foot-diameter evaporation pan. Measured in inches per year.

PERCHED WATER TABLE. A water table, usually of limited area, maintained above the normal free water elevation by the presence of an intervening, relatively impervious, confining earth layer.

PERCOLATION. The movement of gravitational water through soil.

PIEZOMETER. An instrument for measuring pressure head, usually consisting of a small pipe tapped into the side of a closed or open conduit and flush with the inside. It is connected to a pressure gage, water column, or other device for indicating pressure head. May also be a small-diameter well placed in an aquifer.

PILLAR. In situ rock between two or more underground openings.

PIPING. Erosion by percolating water in a layer of subsoil, resulting in caving and the formation of narrow conduits, tunnels or pipes.

PLANT ASSOCIATION. Plant community of definite composition, presenting a uniform physiognomy and growing in uniform habitat conditions.

PLUTONIC. Of igneous origin.

PORE. Interstice or void; a space in rock or soil not occupied by solid mineral matter.

POROSITY. The ratio (usually expressed as a percentage) of the volume of voids in a given mass to the total volume of the mass.

PORTAL. The surface entrance to a decline or an adit.

POTENTIOMETRIC SURFACE. An imaginary surface representing the total head of ground water above a reference level for a particular area, and defined by the level to which water will rise in a well drilled in that area. (Synonym, piezometric level.)

PRESSURE. Force per unit area applied to the outside surface of a body.

PRESSURE HEAD. Equivalent to the height of a column of water that can be supported by the pressure.

PROTORE. As used in this EIS, a component of the Jackpile Sandstone. This component material was stockpiled during mining because it contains elevated but sub-economic uranium concentrations that might become economical to process at some future time because of rising prices or improved technology. At the Jackpile-Paguate mine, the protore contains .02 to .059 percent uranium (U_3O_8).

RAD. The special measurement unit of absorbed dose; the quantity of any type of ionizing radiation that imparts a dose of 100 ergs to 1 gram of tissue (from Radiation Absorbed Dose).

RADIATION. Particles or energy emitted from the nucleus of a radioactive atom.

RADIATION AREA. Any area accessible to individuals in which a major portion the body could receive, in any one hour, a dose in excess of 5 millirems (mrems) or, in any 5 consecutive days, a dose in excess of 100 mrems.

RADIOACTIVE MATERIAL. Any material (solid, liquid or gas) that emits radiation spontaneously.

RADIOACTIVITY. The disintegration of unstable atomic nuclei by the emission of radiation.

RADIUM-226. A radioactive metallic element in group II of the periodic system; one of the alkaline-earth metals. Radium resembles barium in its chemical properties.

RADIUS OF INFLUENCE (OF A WELL). The distance from the center of a pumping well to the closest point at which the ground water is not lowered.

RADON-222. A heavy, radioactive gaseous element. It emanates from (i.e., is a daughter product of) radium-226. Radon has a half-life of 3.823 days and is an alpha particle emitter.

RAISE. An opening, like a shaft, made in the back (roof) of an underground level to reach a level above.

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REM. A measure of the dose of any radiation to body tissue, in terms of its estimated biological effect relative to a dose of 1 roentgen (R) of X-rays (from Roentgen Equivalent Man). One millirem (mrem) = 0.001 rem.

RESTRICTED AREA (CONTROLLED AREA). Any area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

ROCK. Geologically, any naturally formed aggregate of mineral matter constituting an essential and appreciable part of the earth's crust.

ROCKFALL. The relatively free falling of a newly detached segment of rock of any size from a cliff, steep slope, or underground opening.

ROENTGEN. The unit of exposure. The quantity of X- or gamma radiation that produces ions carrying 1 electrostatic unit (esu) charge of either sign (+ or -), in 1 cubic centimeter of dry air at standard temperature and pressure.

ROOM. A wide working place in a flat mine (corresponds to a stope in steep vein).

ROOM AND PILLAR MINING. Method of underground mining where drifts are driven on a regular pattern leaving pillars to support the overburden. The pillars are usually removed at the end of mining in that area.

SAFETY FACTOR. The ratio of forces available to resist slope failure and the forces tending to cause this failure.

SCALE. The proportionate size relationship between an object and the surroundings in which the object is placed. Also, to remove surface loose rock from excavation faces.

SCALED DISTANCE. A factor in blast design, equal to the actual distance from the blast in feet divided by the square root of the explosive weight in pounds.

SEEPAGE. See Percolation.

SEISMIC. Pertaining to, characteristic of, or produced by earthquakes or earth vibration (as from blasting).

SET. A frame for supporting the ground around a shaft, tunnel or other excavation.

SHAFT. A vertical or steeply inclined excavation or opening from the surface down through the strata to the mineral to be mined.

SILL. An igneous intrusion that parallels the planar structure of the surrounding rock (See Dike).

SINUOSITY. The ratio of a river's channel length to the length of its valley.

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JACKPILE-PAGUATE URANIUM MINE RECORD OF DECISION COMPLIANCE ASSESSMENT

September 2007

Prepared for:
Pueblo of Laguna

Prepared by:
OA Systems Corporation

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JACKPILE - PAGUATE

Uranium Mine Reclamation Project

RECORD OF DECISION

DECEMBER 1986

US DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT
ALBUQUERQUE DISTRICT OFFICE

BUREAU OF INDIAN AFFAIRS
ALBUQUERQUE AREA OFFICE

The following measures are approved as the minimum level of reclamation required under the scope of the Record of Decision:

1. Pit Bottoms

   A. Backfill Levels

   Pts will remain as closed basins. Pit bottoms will be backfilled to at least 10 feet above the Dames and Moore (1983) projected ground water recovery levels as indicated below. A schematic diagram is shown in the FEIS, Appendix A (Figure A-1, DOI Proposal).

Proposed Minimum Pit Backfill Levels	
Jackpile	5939'
North Paguate	5958'
South Paguate	5995'
South Paguate (SP-20)	6060'

   A groundwater recovery level monitoring program will be implemented. Additional backfill will be added as necessary to control ponded water. The duration of the monitoring program will be a minimum of 10 years.

   B. Backfill Materials

   Backfill materials will consist of protore, waste dumps H and J, and excess material obtained from waste dump resloping and stream channel clearing. These materials will be covered with 3 feet of overburden and 2 feet of topsoil (i.e., Tres Hermanos Sandstone or alluvial material).

   C. Stabilization

   All backfill slopes will be reduced to no greater than 3:1 (horizontal to vertical). Surface water control berms will be constructed within pit bottoms to reduce erosion and retain soil moisture for plant growth. Surface runoff will also be directed to small retention basins in the pit bottoms. All areas in the pits will then undergo surface shaping, topsoil application and seeding as outlined under "Revegetation Methods" below.

   D. Post-Reclamation Access

   Human and animal access to pit bottoms will be prevented. Livestock grazing will be prevented with the use of sheep-proof fencing due to the uncertainties of predicting radionuclide and heavy metal uptake into plants (forage).

2. Pit Highwalls

   A. Jackpile Pit Highwall

   The top 15' of highwall will be cut to a 45 degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. A schematic diagram is shown in the FEIS, Appendix A (Figure A-7).

   B. North Paguate Pit Highwall

   The top 15' of highwall will be cut to a 45 degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. A schematic diagram is shown in the FEIS. Appendix A (Figure A-7). Additionally, the highwall will be fenced with 6-foot chain link.

   C. South Paguate Pit Highwall

   The top 15' of highwall will be cut to a 45 degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. A schematic diagram is shown in the FEIS, Appendix A (Figure A-7). Additionally, the highwall will be fenced with 6-foot chain link.

3. Waste Dumps

   Waste dumps H and J will be relocated to Jackpile pit as backfill. Most dump slopes will be reduced to 3:1 or less and the dump slopes will be contour furrowed; exceptions are noted in

Table 1-4 of the FEIS. Dumps which have Jackpile Sandstone on their outer surface and any Jackpile Sandstone exposed during resloping will be covered with 3 feet of overburden and 16 inches of topsoil. Dumps that do not contain Jackpile Sandstone on their outer surfaces will be covered with 18 inches of topsoil. Berms will be installed on all dump crests to control erosion. All dump tops will slope slightly away from their outer slopes. Dump slopes will be contoured so their toes are convex to prevent formation of major gullies on slopes. Additional surface treatment is outlined under "Revegetative Methods" below. Detailed modifications and treatments are presented in Table 1-4 of the FEIS. A schematic diagram is shown in the FEIS, Appendix A (Figure A-9).

4. Protore Stockpiles

   All protore will be used as backfill material in pit areas. Backfill will be covered with 3 feet of overburden and 2 feet of Tres Hermanos Sandstone or alluvial material.

5. Site Stability and Drainage

   A. Stream Stability

   All contaminated soils and fill material within 100 feet of the Rio Paguate west of its confluence with the Rio Moquino will be excavated and relocated to the open pits. For the Rio Moquino, waste dumps S, T., U., N and N2 will be pulled back 50 feet from the centerline of the stream channel. The toes of these dumps will be armored with riprap. A concrete drop structure will be constructed across the Rio Moquino approximately 400 feet above the confluence with the Rio Paguate.

   B. Arroyo Headcutting

   Arroyos south of waste dumps I, Y and Y2, and the arroyo west of waste dumps FD-1 and FD-3 will be armored as shown in the FEIS, Appendix A (Figure A-13). Other headcuts encountered during reclamation will also be stabilized by armoring.

   C. Blocked Drainages

   Waste dump J and protore stockpiles SP-17BC and SP-6-B will be removed to unblock ephemeral drainage on south side of minesite. Two blocked drainages north of FD-1 and F dumps will remain blocked. Remainder of minesite, excluding open pits, will drain to Rios Paguate and Moquino.

6. Surface Facilities/Structures

   A. Lease No. 1 (Jackpile Lease)

   All buildings on Lease No. 1 will be demolished and removed except for the Geology building, miner trainer center and buildings at Old Shop and the Open Pit offices. The land surface (except pit highwalls and natural outcrops) will be cleared of radiological material (e.g., Jackpile Sandstone) until gamma readings of twice background or less are achieved. These areas will then be graded and seeded.

   B. Lease No. 4

   All structures and facilities associated with P-10 Mine and New Shop, including all buildings, roads, parking lots, sewage systems, power lines and poles will be left. All operational and maintenance equipment, including tools, machinery, supplies will be removed. All permanent structures and land surfaces (except pit highwalls and natural outcrops) will be cleared of radiological material until gamma readings of twice background or less are achieved. These areas will then be graded and seeded. Nonsalvageable contaminated buildings and materials will be removed to the pits for disposal.

   C. Access Routes

   The four major roads within minesite will be cleared of radiological material and left after reclamation for post-mining use. These access routes include: 1) access road from P-10 and

New shop to State Highway 279; 2) main road through mine; 3) road that passes between housing area and North Oak Canyon Mesa and then proceeds to P-10; and 4) road to Jackpile Well No. 4. All other roads (except on Lease No. 4) will be removed. These areas will then be graded and seeded.

D. Water Wells

Jackpile Well No. 4, P-10 Well, New Shop Well and Old Shop Well, and 3 wells and their associated sheltering structures (near housing area) will be left. The pumps, riser pipe, wiring and water storage tanks will be removed. Wells established for future monitoring purposes will also be left. All wells will be capped to prevent dust, soil and other contaminants from entering the well casing.

E. Rail Spur

The rail spur will be left intact and cleared of radiological material until gamma readings of twice background or less are achieved. Quirk loading dock will be demolished and hauled to the pits.

7. <u>Drill Holes</u>

All drill holes will be plugged according to the State Engineer's requirements. A 5-foot surface concrete plug will also be placed in each hole. Any cased holes will have the casing cut off at the surface. In addition, areas around drill holes will be seeded. Any exploration roads not wanted by the Pueblo will be reclaimed.

8. <u>Underground Modifications</u>

A. Ventilation Holes

Vent holes will be backfilled with waste material (Dakota Sandstone and Mancos Shale) to within 6 feet of surface. Surface casing will be removed, steel support pins installed in walls of vent holes, and sealed with a 6-foot concrete plug from backfill to surface. Areas around vent holes will be contoured and seeded.

B. Adits and Declines

A concrete bulkhead will be constructed approximately 680 feet below portal of P-10 decline. The decline will be backfilled from bulkhead to ground surface with Dakota Sandstone and Macos Shale. Sufficient material will be placed over the portal to allow for compaction and settling. The ground surface above the buried portal will be sloped and then top-dressed and seeded. The Alpine mine entry will be bulkheaded and backfilled. Mine entries not previously plugged by backfilling will be covered. Additionally, the H-1 mine adits will be bulkheaded and backfilled and the adits at the P-13 and NJ-45 mines will be backfilled.

9. <u>Revegetation Methods</u>

A. Top Dresssing

Following final sloping and grading, pit bottoms will be top dressed with 24", waste dumps with 18" and all other areas within the minesite with 12" of material composed primarily of Tres Hermanos Sandstone (stockpiled at three locations within minesite). In order to meet top dressing volume requirements for the northern portion of the minesite, additional material may be obtained from a topsoil borrow area in the Rio Moquino floodplain comprising 44 acres. For the southern portion of the minesite, additional topsoil borrow material located east of J and H dumps may be needed. Following topsoil removal, disturbed borrow areas, will be contoured, fertilized, seeded and mulched.

B. Surface Preparation

After applying top dressing, areas to be planted will be fertilized, followed by disking to a depth of 8 inches and then contour furrowing.

C. Seeding and Seed Mixtures

Before seeding operations begin, the entire minesite will be fenced to prevent livestock grazing. In most situations, seed mixtures will be planted with a rangeland drill. Broadcast seeding combined with hydromulching may be used on inaccessible sites or if determined to be more feasible than drilling. For both methods, the seed mixture will consist mainly of native plant species possessing qualities compatible with post-grazing use and adapted to local environment (Tables 3-10 and 3-11, FEIS). Following drill seeding, straw mulch will be applied at about 2 tons per acre, and crimped into place with a notched disk.

D. Revegetation Success

Using the Community Structure Analysis (CSA) or comparable method, plant establishment will be considered success when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover and production of undisturbed reference areas (but not sooner than 10 years following seeding). Livestock grazing will be prevented until 90 percent comparability values are met. At the end of the 10-year monitoring period, if an unsuccessful trend is shown retreatment may be necessary to achieve success criteria. In the pit bottoms, vegetation will be sampled annually for radionuclide and heavy metal uptake.

10. <u>Monitoring</u>

The monitoring period will vary for each parameter. Existing monitoring activities to be continued will include: meteorologic sampling, air particulate sampling, radon sampling (ambient), radon exhalation sampling, gamma survey, soil and vegetation sampling, water monitoring and subsidence. In addition, the monitoring program will be expanded to include: radon daughter levels (working levels) in any remaining mine buildings and ground water recover levels/salt build-up in the open pits. The ground water monitoring period will be of sufficient duration to determine the stable future water table conditions. Refer to Table 1-5 of the FEIS for details of the monitoring plan as described under the Preferred Alternative.

11. <u>Security</u>

Control of minesite access and security will continue during reclamation and monitoring activities. However, security during monitoring phase will require cooperation from Pueblo of Laguna and BIA to prevent livestock grazing on revegetated sites.

12. <u>Reclamation Completion</u>

Reclamation will be considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover and production of undisturbed reference areas (but not sooner than 10 years following seeding). In addition, gamma radiation levels must be no greater than twice background over the entire minesite. Outdoor radon – 222 concentrations must be no greater than 3pCI/l. Radon daughter levels (Working Levels) in any remaining surface facilities must not exceed 0.03WL.

13. <u>Post-Reclamation Land Uses</u>

Limited livestock grazing, light manufacturing, office space, mining and major equipment storage will be allowed. Specifically excluded are habitation and farming.

I. BACKGROUND AND OVERVIEW

OAS Systems Corporation (OAS) was tasked by the Pueblo of Laguna to perform an independent, third-party review and assessment of the overall conformance of reclamation activities carried out at the Jackpile-Paguate Mine (the "site") to those specific requirements as put forth in the site's 1986 Record of Decision (ROD) (*"Jackpile – Paguate Uranium Mine Reclamation Project Record of Decision"*, U.S. Department of the Interior, December 1986).

The Jackpile-Paguate Mine was primarily a multiple open-pit (3 pits) uranium mining operation developed on Pueblo of Laguna lands by the Anaconda Mining Company (previously Anaconda Copper Company). In late 1952, Anaconda negotiated exploration agreements and mining leases with the Laguna Indian Reservation, and mining commenced in 1953 at the Jackpile open pit, with operations subsequently expanding to include the North Paguate and South Paguate pit areas. Mined ore was transported approximately forty miles northwest to Anaconda's Bluewater Mill (northwest of Grants). In addition to open pit mining of uranium ore, Anaconda also conducted limited underground development and, circa 1969-70, pilot-scale applications of in situ uranium leaching utilizing sulfuric acid. At one time, the Jackpile-Paguate Mine was the largest open-pit uranium mine in the world. It produced 24 million tons of uranium ore. Four hundred million tons of rock was moved during the mining operation. Approximately 3,000 acres of the 7,000 acres leased were disturbed. Approximately 2,700 acres were reclaimed. Mining at the Jackpile-Paguate Mine was terminated in 1982 due to depressed uranium prices. Reclamation of the mine site commenced in 1990. Features such as roads, rivers, fence lines, dumps and monitoring points were added to a 2003 aerial photograph and a 1995 topographic base map to create Exhibits 1 and 2, respectively. These exhibits will be referenced frequently in this report.

II. RECORD OF DECISION REQUIREMENTS

The need for reclamation of the mine was identified in the *"Jackpile-Paguate Uranium Mine Reclamation Project Final Environmental Impact Statement"*, Volumes 1 and 2 (FEIS), completed in October1986. The subsequent *"Jackpile-Paguate Uranium Mine Reclamation Project Record of Decision"* (the ROD) was jointly issued by the U.S. Department of Interior's Bureau of Land Management (BLM) and the Bureau of Indian Affairs (BIA), respectively, in December 1986. The ROD evolved primarily from analyses and findings detailed within the October 31, 1986 FEIS for the site, as prepared by BLM and BIA and filed with the U.S. Environmental Protection Agency (EPA). However, consideration of public comment and subsequent technical discussion and analyses among BLM and BIA specialists also contributed to defining the "preferred alternative" (and subsequently, the ROD). As a result, the ROD-specified "preferred alternative" represented a combination of reclamation procedures that best reflected or achieved the intent of the ROD "Decision Factors", more appropriately described as site reclamation objectives. The Decision Factors, in order of importance, were stated in the ROD to include the following:

- Ensure human health and safety;
- Reduce the releases of radioactive elements and radionuclei to as low as reasonably achievable;
- Ensure the integrity of all existing cultural, religious, and archeological sites;
- Return the vegetative cover to a productive condition comparable to the surrounding area;
- Provide for additional land uses that are compatible with other reclamation objectives and that are desired by the Pueblo of Laguna;
- Eliminate the need for post-reclamation maintenance;
- Blend the visual characteristics of the mine site with the surrounding terrain; and,
- Employ the Laguna people in efforts that afford them opportunities to utilize their skills or train them as appropriate.

In general, the "preferred alternative" reclamation plan incorporated the following components: (i) backfilling of open pit areas to at least ten feet above projected groundwater recovery levels using protore and waste rock dump material; (ii) slope reduction on the upper fifteen feet of pit highwall slopes; (iii) recontouring and covering of remaining waste rock dumps; (iv) completion of arroyo drainage improvements and erosion controls; (v) decontamination of those structures to remain, and removal/disposal of all non-essential structures; (vi) plugging and bulkheading of underground ventilation raises and decline portals, respectively; (vii) reclamation of miscellaneous features such as wells, access roads, rail spur, drill holes, etc.; (viii) site wide revegetation of disturbed areas; and, (ix) provision of site security and long-term monitoring of reclamation success for a period of not less than ten years.

Following successful negotiation of agreements with the Anaconda Mining Company (the prior operator of the Jackpile-Paguate Mine) and the U.S. Department of Interior, Bureau of Indian Affairs (as Trustee), the Pueblo of Laguna accepted the terms and conditions as described in the *"Cooperative Agreement Pursuant to "638"*, adopted on March 24, 1987, to Perform the Management, Coordination, and Administration of the Jackpile-Paguate Reclamation Project on the Laguna Indian Reservation, Cibola County, New Mexico *("Pueblo of Laguna, Reclamation Project Agreements, Section 3-Cooperative Agreement between the Bureau of Indian Affairs and the Pueblo of Laguna"* [Cooperative Agreement Pursuant to "638"], December 5, 1986. Thus, the Pueblo of Laguna was authorized to conduct all aspects of site reclamation at the Jackpile-Paguate Mine.

The Board of Directors for Laguna Construction Company (LCC) was established in June 1988 to reclaim the Jackpile Mine. Officers and key personnel were hired in late 1988 through early 1989. Approximately 10 million dollars worth of equipment was purchased for the project. The Jackpile reclamation began on August 15, 1989 and completed on December 31, 1995, one year ahead of schedule at a cost of approximately 45 million dollars.

As described above, the ROD prescribed specific actions to be carried out with respect to the various mine features. These actions were to be followed by site-wide revegetation of disturbed areas. Under the terms in the ROD, Section 12, Reclamation Completion, reclamation is to be considered complete when *"revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding). In addition, gamma radiation levels must be no greater than twice background over the entire mine site. Outdoor radon-222 concentrations must be no greater than 3 pico Curies/liter. Radon daughter levels (i.e., working levels or "WL") in any remaining surface facilities must not exceed 0. 0.03WL."*

III. OAS APPROACH

Since there was no formal regulatory reporting during the reclamation and post-closure monitoring period, the first OAS endeavor was to assess and organize available data on the reclamation and monitoring activities. This was done by an initial site visit to the Laguna Pueblo to:

- meet with the Pueblo representatives ; Governor Roland Johnson, Chief of Operations Jim Hooper, and Environmental Manager Barbara Cywinska-Bernacik to formalize the scope of the project;
- meet with Jackpile – Paguate Mine Reclamation Project participants: BIA - Al Sedik and Laguna - Marvin Sarracino;
- review the available project documents; and
- tour the project site.

Prior to the meeting, OAS developed a matrix of ROD requirements versus likely data sources (Appendix A, Table A-1). Many of these sources proved to be unavailable. The Laguna Construction Company (LCC) organized its documentation around construction activities and work unit closeouts in order to justify progress payments. Without required periodic regulatory reporting requirements, there was no impetus to organize documentation around environmental requirements outlined in the ROD. Although, the Jacobs Engineering Group, Inc., *"Jackpile Project, Final Environmental Monitoring Plan"*, August 1989 (Jacobs Environmental Monitoring Plan) provided for annual Environmental Reporting, only a single annual report (1996) was found (Pueblo of Laguna, Reclamation Project Manager, *"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Annual Report"*, 1996). Likewise, only a single quarterly report was located (*"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Environmental Monitoring and Regulatory Compliance, Status Report No. 20"*, December, 1994-February, 1995). A tactical modification was made to try to piece compliance through other sources that included raw lab and field data, construction work unit reports and letter authorizations, field inspections and photographs, and verbal testaments of activities by project personnel.

SUBSTANTIATING ROD COMPLIANCE

PRIMARY – (1) Review Field and Lab Data

↓

PRIMARY – (2) Review Documents (Letters, Monthly Reports, and other Reports)

↓

SECONDARY – (3) Check Work Unit Sign-offs and Approved Expenditures

↓

SECONDARY – (4) Review Photographs (Aerials and others)

↓

TERTIARY – (5) Gather Statements from Project Professionals

As with most construction projects, a work breakout schedule was established, which quantified construction activities. There were approximately 300 work items tracked. Physical locations that were called out one way in the EIS and ROD were broken down into sub areas and renamed to match the Reclamation Project work breakout. OAS reviewed the EIS maps and compared those to the maps within the Project Status Report and devised a comparative table to identify work areas to EIS designated areas (Appendix A, Table A-2). OAS also generated a matrix that relates the work units to the ROD areas (Appendix A, Table A-3).

The monthly reclamation Project Status Reports were submitted to the POL throughout the reclamation period. There are 71 Project Status Reports, which are organized around work items. These reports contained maps of various work areas, percent completion within the work areas, photos of noteworthy activities, problems identified, change orders, and work item closeouts.

There are discussions within the Project Status Reports of design changes and variations that *"meet the intent of the ROD"*. These are generally in the form of letters of transference of a design change or discussion forwarded to the BIA and POL for review or approval. The design packages that were actually submitted were not attached to the Project Status Reports that OAS received. When a reference to a letter of approval was discussed in the Project Status Report, it was impossible to link that acceptance to a specific design change. There were no letters available with attachments that stated that there was a deviation from the ROD requirement and delineating the accepted change with a three party signature. The Change Orders listed were for quantity changes that affected the contract price.

As each work item was completed, field inspections by the three agencies (Pueblo of Laguna, Bureau of Indian Affairs, and Laguna Construction Company) were conducted and all three agencies signed off on each work item, signifying agreement with the manner of the work, completeness of the work and payment approval. This is the only formal documentation of approvals of work that could be found. Pueblo of Laguna, *"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico"*, Volume 1 of 2 – Completed Work Packages, 1989-1991, contains the signoff forms from the 3 agencies approving closeout of a work item and payment approval. Volume 2 of 2 was never located. To supplement this document, OAS reviewed each Project Status Report and logged whether activity took place on that work unit and if it was listed as closed out. The matrix tracking the work unit progress is presented in Appendix A, Table A-4. This table is used to indicate the approval of the work by the three agencies, each of who had a field inspector. Absent more direct documentation, OAS has used the Project Status Report summaries to indicate that the parties involved signed off on the work as either conforming to the requirements of the ROD or an authorized deviation from the ROD.

IV. ROD COMPLIANCE

Most current RODs are prepared in a manner that specifies certain environmental criteria that must be met, but do not specify the methods required to meet the environmental goals. The Jackpile ROD was written in a different manner in that it specified certain engineering approaches that were to be initiated during reclamation, which would meet the goal of stability and the protection of human and animal health and safety rather than specifying environmental compliance thresholds. Consequently, there were some difficulties in determining if compliance with the ROD items was met. There were instances in which the letter of the ROD was met but the intent was not met. Conversely, there were cases in which the letter of the ROD was not met, but the intent or goal of the ROD was met.

For an example of the first instance, the ROD specified that an erosion control structure was to be installed along the Rio Moquino. The structure was installed as required, but the bank below the toe of the waste pile is eroding in spite of the control structure. If the erosion continues, the waste pile could be compromised at some time in the future, which is contrary to the intent of the ROD.

There are also a couple of examples that were evaluated in which the prescribed engineering design was not performed, but in which the goal of the ROD was met. The first involved an area on the Rio Moquino where a structure designed to prevent headcutting was not installed, but the in situ sandstone formation prevented further erosion. A second instance where the letter of the ROD was not followed but the intent was met, was where a gabion drop structure was to be installed on the Rio Moquino at a road crossing. The Rio Moquino washed out of its old channel and the rivers' new channel does not require an erosion control structure to prevent exposure of the waste pile.

In general, the purpose of the OAS evaluation of whether the approach to each ROD item was compliant or non-compliant, was to determine whether the intent of the ROD was met rather than the letter of the ROD.

In this section, the ROD is examined point by point for compliance. Where there is direct proof of compliance it is presented and referenced. Where there is deviation from the ROD, justification is presented where there is authorization documented or implied through contractual signoffs. If there appear to be unauthorized deviations, then discussions present potential impacts of the deviation.

It should be noted that the Reclamation Team recognized that strict compliance to the letter of the ROD was not anticipated, as reflected in the following from a May 9, 1990 summary of recommendations that were forwarded to the POL Council and BIA for approval. (*"Jackpile Reclamation Project, Final Design Recommendations for BIA Approval"*, May 9, 1990, pg 2, ¶ 4).

> *"These items are felt to be within the "spirit" of the ROD and consistent with the Decision Factors (Page 3 of the ROD) but may not necessarily be to the "letter" of some of the specifics in the ROD Measures. However, enough new information has become available to the responsible parties on the Project (from late 1989 to the present) which have identified opportunities to better meet the longer term goals and objectives in a more cost-effective way utilizing current industry practice. Many of the design conditions have changed since the early and mid-1980's; field conditions at the Jackpile site have been identified which make compliance with the "letter" of the ROD virtually unachievable in some cases and financially burdensome to the POL in others."*

ROD Requirements

The ROD requirements are presented in ***Bold Italics***.

1. ***PIT BOTTOMS***

   A. ***Backfill Levels:***

      1. ***Pits will remain as closed basins. Pit bottoms will be backfilled to at least 10 feet above the Dames and Moore (1983) projected ground water recovery levels as indicated below. A schematic diagram is shown in the FEIS, Appendix A (Figure A-1, DOI Proposal):***

Pit:	***Proposed Minimum Backfill Level:***
Jackpile 41	***5,939 ft. amsl***
North Paguate 20	***5,958 ft. amsl***
South Paguate 34	***5,995 ft. amsl***
South Paguate 35	***6,060 ft. amsl***

The minimum back fill levels can be confirmed by the survey data presented for ground elevations at the pit wells. The LCC provided the following survey information for the monitoring wells installed in the North and South Paguate Open Pits. Additional wells were installed in the Jackpile Pit in April 2007.

Table 1
Monitor Well Survey Information

WELL ELEVATION			TAKEN: 3-31-92 By: LCC, Inc.	
LOCATION	**N**	**E**	**GROUND ELEVATION**	**TOP CAP ELEVATION**
North Paguate NP-OP-20 W	1,504,823.95	638,745.96	5966.2	5968.17
North Paguate NP-OP-20 E	1,505,123.28	641,582.11	5961.85	5963.93
South Paguate SP-OP-34	1,500,641.39	637,928.55	5995.04	5997.84
South Paguate SP-OP-35	1,501,033.20	634,954.17	6060.89	6031.21
Jackpile JP-OP-41 S	1,505,868.90	648,232.78	5939.80	5943.40
Jackpile JP-OP-41 N	1,508,348.33	649,080.80	5937.37	5941.07

Based on these provided surveyed finish grade ground elevations at the monitoring wells in the Paguate pits, the elevations match or exceed the minimum elevations proposed by Dames & Moore in the ROD.

Conclusions – All monitoring well installation indicate that the minimum finished grades were achieved.

Recommendations - Based on the fact that backfill elevations in all cases met or exceed the minimum proposed backfill level(s), the ROD objective has been achieved.

2. ***A groundwater recovery level monitoring program will be implemented. Additional backfill will be added as necessary to control ponded water. The duration of the monitoring program will be a minimum of 10 years.***

This item requires that monitoring be performed to assure that the ROD projections were accurate in predicting groundwater elevation recovery levels. There were only four years of groundwater elevation data found for the North and South Paguate Pit Wells. The Jackpile wells were installed in April 2007 and sampling for 2007 indicates all pit wells, except NP-OP-20W, met the 10-foot separation required in the ROD. The NP-OP-20W well was found to have a groundwater elevation of less than five feet consistently, as indicated in bold in the following table.

Table 2
Groundwater Elevations in Pits

Wells	NP-OP-20E	NP-OP-20W	SP-OP-34	SP-OP-35	JP-OP-41N	JP-OP-41S
Dates						
1996						
1997						
1998						
1999	29.91	**3.88**	19.4	75.5		
2000						
2001						
2002						
2003						
2004	31.87	**4.35**	18.15	81.33		
2005	31.62	**3.29**	17.6	71.57		
2006	31.4	**3.33**	17.46	70.88		
2007	31.80	**4.22**	19.04	70.86	32.85	38.99

Blank fields indicate no data was provided

Discussion - From the OAS site inspection, there is a permanent pond/wetland area in the North Paguate pit. A photograph of this ponded area is found in Appendix B, Photo B-1. This photo contains the NP-OP-20W well shown near the ponded area. The water table elevation of that well is not compliant with the ROD. The ponding is also evidenced by aerial photos (Appendix E) and established wetland vegetation species. Although, the Jacobs Environmental Monitoring Plan required that all ponded water within the pits be monitored annually for chemical constituents, there was no water quality data for this ponded area. A sample was collected from the NP Pond in 2007 which indicates elevated concentrations of radiologicals. These results are discussed in Section 10-Monitoring. Additional sampling and assessment of this situation will be needed to draw conclusions on the risk to humans, wildlife or domestic stock.

2006 was a very wet year with significant standing water in all three pits for most of the summer's duration.

Conclusions - Based on the fact that there is little elevation data where ten years of data are required and only one sample of the ponded water, accordingly, this aspect of site reclamation is considered ***non-compliant*** with the requirements of the ROD.

Recommendations -

- During preparation of this report, OAS made the recommendation that the two wells required by the ROD should be installed in the Jackpile Pit. This was done in April 2007
- Water table elevations should be monitored over a number of years to determine if the levels have stabilized, or are increasing or declining in order to evaluate whether the 10-foot below surface requirement is being met.
- Ponded water, wherever found within the pits, should be collected for chemical and radiological analysis.

These data can then be used to assess the risk of ponded water. The data can then be analyzed to determine if the water is groundwater or surface water and whether the chemical constituents or radiological levels present a threat to wildlife, domestic stock, or humans. As wetland areas are diverse ecosystems that are widely valued, it may be prudent to leave the North Paguate area as a wetland if the risk analysis so justifies. If chemical or radiological analysis indicates an unacceptable risk, then the ROD requirement to add additional fill to low areas would be warranted.

B. *Backfill Materials:*

Backfill materials will consist of protore, waste dumps H and J, and excess material obtained from waste dump resloping and stream channel clearing. These materials will be covered with 3 feet of overburden and 2 feet of topsoil (i.e. Tres Hermanos Sandstone or alluvial material).

Waste Dumps H and J were not moved into the pits. Per M. Sarracino, their volumes were not required and the distance to move them was deemed prohibitive. Waste Piles H and J were sloped/terraced/seeded. Photos B-2 and B-3 show stable, vegetated waste piles H and J, respectively.

Project Status Reports document protore movements in the North Paguate, (Report No. 20), South Paguate (Report No. 26) and Jackpile (Report No. 43) Pits.

Activity codes in group 2E1 were authorized for payment for backfill movement. Table A-3, Appendix A, delineates which protore and waste piles were affiliated with which work units. Based on the Project Status Reports, backfilling took place in the following time frames:

Jackpile Pit	May 1991 through December 1994
North Paguate Pit	November 1991 through April 1991
South Paguate Pit	September 1990 through September 1991

There were approved design changes for required cover depths that are described later in Section 3c.

Conclusions - Although, Dumps H and J were not moved, there appears to be substantial compliance to the ROD. There was sufficient backfill material in proximity to the pits that Dumps H and J volumes were, in fact, not needed. The cover, slopes, and vegetation on these waste piles appear to be stable.

Recommendations – No further activities are recommended at this time.

C. *Stabilization:*

All backfill slopes will be reduced to no greater than 3:1 (horizontal to vertical). Surface water control berms will be constructed within pit bottoms to reduce erosion and retain soil moisture for plant growth. Surface runoff will also be directed to small retention basins in the pit bottoms. All areas in the pits will then undergo surface shaping, topsoil application, and seeding as outlined under "Revegetation Methods" below.

1. Sloping

Project Status Report No. 11, dated June 1990, included remarks relating to changes in the sloping requirements listed in the ROD. This includes summary milestones (Section 2.4 MILESTONES):

- *"Michael Bone, P.E. of Roy F. Weston, Inc. submitted the final design criteria for slope heights, lengths, and terracing specifications."*

- *"Water Mills (Acting Asst. Secretary, Bureau of Indian Affairs, Washington, D.C.) formally approved the design changes submitted to George Farris in May 1990. These design changes will be incorporated into all future planning efforts."*

Project Status Report No. 11 also contains a memorandum (attachment) received June 12, 1990 from Acting Assistant Director of Indian Affairs, Walter Mills approving the design changes (pg 2, ¶ 2 & 3):

"On May 15, 1990, a new reclamation design criteria was presented by Landmark/Weston for BIA approval. This design criteria is important in that it sets basic design criteria while allowing for the flexibility necessary for the LCC and the Bureau to make some decisions on a case-by-case basis. The re-design will also eliminate the long slopes that are now required and at the same time result in a more stable slope design. This will also allow the project to blend more aesthetically with the surrounding topography.

Because we view this as an improvement on the existing design, I hereby approve the criteria set forth by Landmark/Weston on May 15. If there are any questions or if you need further assistance on this matter, please contact Mr. George R. Farris at FTS 268-4791."

Conclusions - There appears to be ***non-compliance*** to the letter of the ROD requirements in regard to the sloping. But many deviations were approved. It is difficult to determine pile by pile what exactly was done according to the ROD 3:1 sloping requirement and/or in accordance with the approved changes. In the OAS site inspection, there were no observed problems with the slope grades. Although there are deviations to the ROD, they appear to have met the intent of the ROD.

Some of the long runs of the terracing do appear to cause chronic blow-outs in some areas due to the pressure head of water building up along the terrace berm. The terracing problem is further discussed in Section 3c of this report.

Recommendations - There are no corrective actions recommended

2. Pit Berms and Retention Ponds

After reclamation was complete, the pit bottoms were contoured and there is no evidence that berms or retention ponds were installed. Therefore, it is unknown if that was done during reclamation.

Conclusions – The pit berms and retention ponds are not believed to be a concern for post closure health and environmental risks.

Recommendations – No further activities are recommended.

D. *Post-Reclamation Access:*

Human and animal access to pit bottoms will be prevented with the use of sheep-proof fencing due to the uncertainties of predicting radionuclide and heavy metal uptake into plants (forage).

The reclamation construction specifications (Jacobs Engineering Group, Inc., "*Jackpile Project, Construction Specifications*", August 1989) detailed a different type of fencing: four strand barbed wire, as shown in the project specifications. (Division 2, Sitework, Section 02833, Fences and Gates, pg. 2-36)

"2.1 MATERIALS

A. Reusable materials salvaged from demolition work specified in Section 02060 shall be utilized, to the extent practical, in the construction of the fence and gates specified in this section.

B. Fencing shall include posts, barbed wire, and all appurtenances and accessories required for complete installation.

C. Barbed wire shall conform to the requirements of ASTM A121, and shall consist of four lines of double stranded 12 ½-gage galvanized wire with *either 2-point or 4-point barbs spaced at 5-inch intervals. Galvanizing shall be Class 3.*

D. *Line post shall be galvanized tee, channel, or U-bar shapes, 1.33 pounds per foot.*

E. *Braces shall be 9-gage wire, twisted to tighten.*

F. *End, corner, and pull posts shall be 2-inch Schedule 40 galvanized steel pipe, or galvanized steel angle section 2 ½ x 2 ½ x ¼ inches.*

G. *Hardware for connecting members shall conform to commercial standards."*

The fencing installed appears to be on the perimeter of the mine site rather than the pit bottoms. The fencing is the four strand barbed wire rather than the sheep-proof fencing called for in the ROD. Photo B-4 in Appendix B, is a photo taken of the fencing as it was installed in September 1990.

Based on Project Status Report No. 32, March 1992, and sightings during inspections of the site in 2006, there appears to be ongoing problems with cattle and horses entering the mine site in general, and the Jackpile pit bottom in particular. The existing fencing does not impede access of domesticated or wild animals.

The OAS 2006 report *"Jackpile-Paguate Uranium Mine Post-Reclamation, Soils and Plant Uptake Analysis"* concludes that vegetation growing on the reclaimed mine presents a minimal potential for hazards to domestic livestock or human health due to the low or normal concentrations of metals and radionuclides.

Based on sampling of the monitoring wells in the North Paguate and South Paguate pits, and the newly installed Jackpile wells, there are very high concentrations of radionuclides in the groundwater. Similarly, the 2007 sampling of the NP Pond indicates high concentrations of radiologicals in that surface water feature, which is readily accessible to grazing animals. Limited well construction information or water table elevation data were available, so conclusions cannot be drawn as to whether the water is surface water in origin, perched water, or true groundwater. Further investigation is necessary to determine the risk involved from access by humans or animals.

Conclusions - There appears to be substantial ***non-compliance*** with both the letter and intent of this Rod requirement. The fencing is clearly inadequate to prevent grazing. Installation of the perimeter fencing was approved in 1989. The perimeter fencing cannot be removed and should be maintained. One or two additional sampling events need to be conducted in the North Paguate pit. Additional backfilling or permanent fence installation at North Paguate may be required based on those sampling events.

Recommendations – Additional monitoring and risk assessment is required to determine if there is any potential for impairment to the natural resources (both water and vegetation) that are needed for grazing domestic animals and wildlife. Pit bottoms need to be fenced until a recommended risk assessment is completed.

2. *PIT HIGHWALLS*

A. *Jackpile Pit Highwall:*

The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris.

B. *North Paguate Pit Highwall:*

The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. Additionally, the highwall will be fenced with 6-foot chain link.

C. *South Paguate Pit Highwall:*

The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. Additionally, the highwall will be fenced with 6-foot chain link.

The Jacobs Environmental Monitoring Plan states that blasting to reduce highwall slopes will be considered "OPTIONAL" work package items dependent on funding and POL desires.

Work on the highwalls started with the highwalls of the South Paguate Pit. There were objections to the blasting from the Paguate Village. Project Status Report No. 9, April 1990, references a Seismic Study and Project Status Report No. 11, June 1990, a Blast Study documenting damage too many of the buildings in the Village. Photos B-5, B-6, and B-7 in Appendix B, show present day conditions of several of the highwalls.

There is a two page document entitled *"Jackpile Reclamation Project, Final Design Recommendations for BIA Approval"* dated May 9, 1990, which summarizes several design variations. A signed copy of approvals and authorizations was not found. The following excerpt relates to the highwalls (pg. 2, ¶ 1).

> *"7) Some highwall trimming and scaling is seen as unnecessary and infeasible in some cases due to natural stabilization along alluvial material (mostly in the South Paguate-west end) and lack of safe access (places to*

safety situate heavy equipment). Along the Jackpile pit crest on Gavilan Mesa (where the presence of extremely competent Tres Hermanos Sandstone has showed no visible weathering or hazardous conditions) the trimming requirement would require blasting. Blasting has already had to be used to stabilize a portion of the South Paguate pit, but objections from the Pueblo on the use of blasting have precluded any future use of it for trimming or scaling."

A memorandum dated April 23, 1991 from J.H Olsen, Jr. to Governor Harry Early documented POL Council approved design changes and recommended forwarding description of changes to the BIA for approval. A signed copy of the approvals and authorizations was not found. One of the changes was to abandon the highwalls and allow them to erode naturally. The following is the relevant excerpt from the 1991 memorandum. (*"Pueblo of Laguna Council, Reclamation Project Issues"*, April 23, 1991, pg. 3, ¶ 2)

c) HIGHWALL TRIMMING & SCALING

Evaluation of the highwall trimming and scaling requirement has prompted questioning of its need and value. Operationally, the activities are extremely difficult to achieve because of inaccessibility and risk to equipment operators. Experience with drilling and blasting techniques in the spring, 1990 proved objectionable due to the potential blast damage in Paguate. (Many highwalls could only be trimmed and scaled with blasting techniques due to the presence of hard sandstone materials on the highwall crests and the danger of putting heavy equipment next to the edges.) Scaling probably loosens up more material than it effectively removes. Trimming of the crests would also enhance erosion since runoff would have more surface area on which to collect and run off. It is recommended that trimming and scaling requirements be suspended since it is judged that, over time, the highwalls will revert to a stable state much the same as natural mesas adjacent to the site which are composed of the same geologic materials. As mentioned, drilling and blasting is the only way to trim and scale some highwalls and the blast damage to structures in Paguate could actually aggravate the problem experienced from the active mining area. The unspent funds from this activity could be used to help repairing already-identified damage."

Work Units covering the trim and scaling of highwalls are 2E5. All work on these activities ceased in December 1991.

Four-foot high chain link fence was installed in the South Paguate area that was blasted. No fencing was observed in any other highwall areas.

Conclusions - This aspect of site reclamation is considered compliant with the desires of the Pueblo of Laguna and the deviation from the ROD requirements is well substantiated with the results of the blast studies. The Jacobs

Environmental Monitoring Plan listed this approach as an option that could be based on the wishes of the Pueblo of Laguna.

Recommendations - A field assessment of the highwalls and Old Highway 279 should be made periodically to make sure that the highwalls do not comprise a threat to normal Pueblo of Laguna activities, or if additional fencing or other corrective measures are required during the erosion process. If significant hazard potential is present, other means of slope reduction should be evaluated, such as ripping, or alternatively, localized berming or other protective measures may be warranted. The south-facing wall at the North Paguate pit also needs to be periodically assessed to assure that it is eroding sufficiently to cover the exposed Jackpile Sandstone, as planned.

3. *WASTE DUMPS*

a. Waste dumps H and J will be relocated to Jackpile pit as backfill.

As discussed in ROD Requirement C above, Waste Dumps H and J were not moved into the pits. Their volumes were not required and the distance to move them was deemed prohibitive. Waste Piles H and J were successfully sloped, terraced and seeded.

b. Most dump slopes will be reduced to 3:1 or less and the dump slopes will be contour furrowed; exceptions are noted in Table I-4 of the FEIS.

As discussed in ROD Requirement C, there are references in several Project Status Reports (Reports No. 1, 6, 7, 9, 11, and 13) regarding variations to 3:1 sloping of waste piles.

A memorandum dated April 23, 1991 from J.H Olsen, Jr. to Governor Harry Early (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)* documented POL Council approved design changes and recommended forwarding description of changes to the BIA for approval. A signed copy of the approvals and authorizations was not found. Some of the changes related to deviations from the 3:1 sloping criteria. The following are the relevant excerpts from that memorandum.

Jackpile Area - (pg. 2, ¶ 1, 2 & 3)

"SPECIAL CASE DESIGN NO. 2- JACKPILE WASTE DUMP JP-WO-03: This dump was originally to be sloped at 3:1 and placement of more topsoil over the entire area. The top of this dump already meets the revegetation standards and as much as is practical will be salvaged when the 3:1 slope is cut. Grading to help channel the runoff to eliminate long term erosion in this area will help its stability. The revised design cost is estimated at this time to be equal to the Jacob's estimate of $330,000 for the sloping work.

"SPECIAL CASE DESIGN NO. 3- JACKPILE WASTE DUMP JP-WS-19: This dump, when sloped to 3:1 would move material off the site onto the Cebolletta Land Grant. To avoid this, the top of the dump will be moved southward into the Jackpile Pit until the height is reduced to allow for 3:1 sloping and keep this material on the Project Site.
Estimated cost for the sloping work is $540,000.

"SPECIAL CASE DESIGN NO. 4- GAVILAN MESA DUMP JP-WS-01: This dump cannot be dozed to 3:1 without blasting the existing mesa which is in the backslope. No provisions for blasting costs and its associated potential shock effects had been made in the original design. This is the most visible dump on the site and the visual characteristics of the finished slope needed to be considered. The recommended approach is to cut the top of the dump down to a level where the natural mesa is exposed; this will blend in with the surroundings and the remaining material will be sloped down to the 3:1 criteria and revegetated. Estimated cost at this time is judged to equal the Jacobs estimate of approximately $340,000."

<u>South Paguate Area</u> - (pg. 2, ¶ 4)

"SPECIAL CASE DESIGN NO. 5- OAK CANYON WASTE PILE SP-WO-06: This dump is north of the LCC shop area and runs along the north side of the Oak Canyon. Sloping of this dump to the 3:1 criteria had several difficulties: destroying and covering up the natural conditions in the canyon, upsetting the already-stable dump by increasing the potential for water runoff, original work schedule for this effort interfered with the topsoil stockpile removal, and the presence in certain spots of natural rock outcroppings which could not be done with existing equipment. The recommended treatment is to leave the dump as is and increase the vegetative cover using hydroseeding techniques. If this operation is not adequate, future sloping and additional topsoil placement could be done at the POL's direction.
Elimination of the sloping/soil cost in the Jacobs estimate is offset by the revegetation expense."

Although the letter of the ROD was not met, the approved modified methods (i.e. sloping) appear to have been put in place successfully. There have been no observed problems associated with the modifications that were implemented.

c. ***Dumps which have Jackpile Sandstone on their outer surface and any Jackpile Sandstone exposed during resloping will be covered with 3 feet of overburden and 18 inches of topsoil.***

The cover requirement for the Jackpile Sandstone was reduced to a 1.0-foot radon cover and 1.5 feet of soil by the construction specifications, as shown below. (Jacobs Engineering Group, Inc. *"Jackpile Project, Construction Specifications"*, August 1989 – Division 2, Sitework, Section 02000, Earthwork, 3.5 Fill Construction, pg. 2-16)

"4. *Cover Construction:*

a. *The Contractor shall place cover material at the locations and related thicknesses shown on the drawings. The requirements listed in Table 1 shall be followed unless otherwise shown on the drawings or directed by the Engineer:*

TABLE 1

Surface Material Thickness	***Radon and Soil Cover***
Mancos Shale	*Soil – 1.5 ft.*
Tres Hermanos Sandstone	*None required*
Alluvium	*None required*
Jackpile Sandstone - Ore Associated Waste (greater than 40 percent of total area – outside of pit)	*Radon Cover – 1.0 ft.* *Soil – 1.5 ft.*
Jackpile Sandstone - Ore Associated Waste (greater than 40 percent of total area – inside of pit)	*Radon Cover – 1.0 ft.* *Soil – 2.0 ft.*
Jackpile Sandstone - Protore (inside of pit)	*Radon Cover – 1.0 ft.* *Soil – 2.0 ft.*
Mixed Material (Jackpile Sandstone less than 40 percent of total area)"	*Soil – 1.5 ft.*

c.(1) <u>Shale Cover</u>

The ROD required numerous areas to be covered with a radon barrier of shale prior to placement of topsoil. The requirements of the ROD are listed in the following table. These areas included both in situ ore left un-mined inside the pits and locations outside the pit from where protore was moved inside the pit. The reclamation team field verified shale layer depths and their measurements are summarized below. The field sheets from which these data were summarized are included in files labeled 'Shale Cover Data' in the project electronic library. The list was reviewed by M. Sarracino, and it appears to be comprehensive and the finished depths in compliance with the ROD requirements.

Table 3
Shale Layer for Radon Cap, Field Verification Depths

LOCATION Measured	JSS-Ore Inside Pit (min. 12")	Protore (min. 12")	Mixed Material (min. none)	Radon Barrier Shale Depth (inches)		Gamma after Shale Placement (mR/h) *
NP-D3-D2	X			min	12	13.7
				max	13.71	
NP-PS-13		X		min	12	No Data
				max	14.14	
NP-PS-14, 15		X		min	12	20.5
				max	12.7	
SP-PS-01		X		min	12	No Data
				max	13.07	
SP-PS-02		X		min	12	13.8
				max	12.3	
SP-PS-38		X		min	12	No Data
				max	12.7	
SP-WO-04			X	min	12	10.9
				max	13.43	
SP-WO-10			X	min	No Data	No Data
				max	No Data	
SP-WO-13			X	min	12	No Data
				max	14.1	

* *Target Gamma concentration after cover placement was less than 2 times background (14 mR/h)*

c.(2) Topsoil

The ROD required numerous areas to be covered with Top Soil to a specified depth. The requirements of the ROD are listed in the Table 4. The reclamation team field verified top soil layer depths and their measurements are summarized below. The field sheets from which these data were summarized are included in files labeled 'Soil Cover Data' in the project electronic library.

Four categories of areas are listed in Table 4:

1.) Mancos Shale - Areas with the letter "S" opposite them are areas that served as sources of shale for radon barrier material. After the material for cover was removed these required 18" inches of topsoil according to the ROD. This appears to have been confirmed.
2.) JSS-Ore Inside Pit – These are areas of in situ un-mined Ore inside the pit which was covered with shale in an earlier step and required 24" of topsoil according to the ROD. There appears to be a deviation from the ROD and a targeted depth of 18 inches of topsoil for this category. It is unclear if this is a documented approved change in requirements.
3.) Protore - Protore stockpiles were placed into the pit and their locations documented for potential future use. These areas like the un-mined ore required

24 inches of topsoil on top of the shale radon barrier. There appears to be a deviation from the ROD and a targeted depth of 18 inches of topsoil for this category. Again, it is unclear if this is a documented approved change in requirements.

4.) Mixed Material – These areas are waste piles outside the pit that were sloped/contoured and covered with 18 inches of material. This is in accordance with the ROD and the depths were confirmed. Within the fourth category is a top soil source area marked "T". This was an area where topsoil was mined for cover. It is an area that should require no cover and not be covered by the ROD.

Table 4
Top Soil Layer, Field Verification Depths

Location Measured	EIS Map Label	Mancos Shale (min.18")	JSS-Ore Inside Pit (min.24")	Protore (min.24")	Mixed Material (min.18")		Top Soil Depth (inches)	Gamma After Shale Placement (mR/h)
JP-PS-24	SP 6a			X		min	20	
						avg	21.7	
JP-WO-06	H				X	min	18	
						avg	19.4	
JP-WO-05	J				X	min	18	
						avg	20.5	
JP-D12	???				X	min	18	
						avg	20.2	
JP-WS-17	FD-1	S				min	18	
						avg	18	
JP-WT-16	???				T	min	18	
						avg	18	
JP-PS-27	J1			X		min	18	
						avg	18	
JP-WS-15	A & B	S				min	18	
						avg	18	
JP-OP-41	Pit Bottom		X			min	18	
						avg	18	
NP-D1	Pit Bottom		X			min	18	10.6
						avg	19.8	
NP-D-2&3	Pit Bottom		X			min	18	
						avg	21.0	
NP-D4, NP-PS-13	SP-1			X		min	18	
						avg	20.83	
NP-PS-16	10. SP-2-D, SP-1-C			X		min	18	
						avg	20.77	
NP-D-5	NP-PS-14, 15			X		min	18	
						avg	19.7	
SP-CS-38	K & L				X	min	18	10.65
						avg	19.77	
SP-WO-04	Q & R				X	min	18	18.46

Location Measured	EIS Map Label	Mancos Shale (min.18")	JSS-Ore Inside Pit (min.24")	Protore (min.24")	Mixed Material (min.18")		Top Soil Depth (inches)	Gamma After Shale Placement (mR/h)
						avg	20.7	
SP-OP-34	Pit Bottom		X			min	18	14.34
						avg	19.11	
SP-OP-35	Pit Bottom		X			min	18	13.9
						avg	20.8	
SP-WS-18C & 20		S				min	18	13.9
						avg	18.5	
SP-PS-01	SP-1A			X		min	18	
						avg	21.1	
SP-PS-02	4-1			X		min	18	9.6
						avg	19.6	
SP-WO-10	Pit Bottom				X	min	18	10.13
						avg	21.17	
SP-WO-13A	Pit Bottom				X	min	18	9.1
						avg	18.9	
SP-WS-37	Pit Bottom	S				min	18	
						avg	20.11	

The topsoil covers were placed on sloped and contoured surfaces and then seeded. The target cover depth for all areas appears to have been 18 inches and 18 inches were achieved The target of less than 2 times background (with background 14 mR/h) appears to have been achieved in areas where it was monitored.

d. Berms will be installed on all dump crests to control erosion. All dump tops will slope slightly away from their outer slopes. Dump slopes will be contoured so their toes are convex to prevent formation of major gullies on slopes.

Erosion control berms were installed. As shown in an early photograph from Project Status Report No. 14, September 1990, Figure 6, B-8 shows the berms as constructed and recent OAS 2006 photos B-9 and B-10, Appendix B, indicate that they continue to retain precipitation event runoff.

Discussion - The berms and contouring are working well except in limited cases where the excessive berm length causes too large a buildup of water resulting in predictable, chronic blow-out areas. Photos B-11 and B-12, Appendix B, show areas of chronic blowouts, due to water build up on long berm runs. The locations presented in Table 5 have been observed by M. Sarracino and Laguna Construction Company (LCC), to have chronic erosion problems. Maps indicating these areas are presented in Appendix C (Exhibits 1 and 2).

Table 5
Areas with Chronic Erosion Problems

LOCATION	DESCRIPTION
Jackpile Area:	Area Y, Y2, X along terraces at, or around, transitions between piles
	Area A, B, FD-3 along terraces at, or around transitions between piles
	Area W & V at the drainage areas against natural mesa
	JP-WS-17, JP-WT-16 Y FD-1 drains along roadways and drains
North Paguate Area:	N2 at east end of drain system
	Area S, T, N at transitions between piles on slopes, drains
South Paguate Area	SP-WS-20, SP-WT-19 along slopes and drainage areas
	SP-WS-17, SP-WS-13A at drainage area
	SP-WS-07 at drainage area
	Q, R, Main Access Road slopes and drainage areas

Conclusions - OAS considers the non-use of dumps H and J (as backfill) to be a non-substantive variance from the ROD requirements, given that the features were otherwise closed in accordance with specified procedures. Issuance of Construction Specifications with alternate cover requirements from the ROD, implies an acceptance of those new depths by the relevant parties. However, the berming design that was implemented for the reclamation did not perform as expected. The areas of chronic erosion blow-outs will be considered non-compliant if radioactive material is exposed or RAD levels exceed the specified limits.

Recommendations - An evaluation of the chronic blowout areas, to determine if solutions can be designed to relieve these continuing maintenance problems, is recommended. Erosion should be monitored with appropriate equipment to determine if radiological safety is a concern. If the underlying material is non-RAD emitting, the slopes may be allowed to erode naturally.

e. ***Additional surface treatment is outlined under "Revegetation Methods" below. Detailed modifications and treatments are presented in Table I-4 of the FEIS.***

Revegetation will be discussed in detail in Section 9 - Revegetation Methods.

4. *PROTORE STOCKPILES*

All protore will be used as backfill material in pit areas. Backfill will be covered with 3 feet of overburden and 2 feet of Tres Hermanos Sandstone or alluvial material.

As discussed in section 3c, the cover depths for the protore were revised by the construction specifications. The cover requirement for protore was established in the specifications, as a 1.0-foot radon cover and 2.0 feet of soil.

Protore was moved under Work Units 2E1N into the North Paguate Pit between December 1989 through closeout in April 1991 (Appendix A, Tables A-3 and A-4).

The quantities for these movements are listed in Project Status Report No. 20, March 1991, attachment.

Protore was moved under Work Unit 2E1S02 into the South Paguate Pit between April and May 1991 (Tables A-3 and A-4). The quantities for these movements are listed in Project Status Report No. 26, September 1991, attachment.

Protore was moved under Work Units 2E1J into the Jackpile Pit between May 1991 through closeout in April 1993 (Tables A-3 and A-4). The quantities for these movements are listed in Project Status Report No. 43, February 1993, attachment.

There are field records available where remediation technicians verified cover depths of shale placed on protore areas and depths of top soil on a variety of areas. These are found in the Library under "Shale Cover" and "Top Soil", respectively. Probes were used and depths recorded on 100-foot by 100-foot grids. In some cases gamma survey results after placement of shale, were also available. Those data are summarized in Tables 3 and 4 above in section 3c.

Conclusions - While the letter of the ROD was not met, the revised shale barrier depth was met in all cases tested. The top soil cover was less than the revised 24 inches, but in all cases it was at least 18 inches. The gamma concentration, after placement of the cover, was below the criteria of twice background levels.

Recommendations - Although the covers did not meet the ROD or the reclamation specifications, the covers appear to be adequate for radiation safety concerns. No further action is recommended.

5. *SITE STABILITY AND DRAINAGE*

A. *Stream Stability:*

1. ***All contaminated soils and fill material within 100 feet of the Rio Paguate west of its confluence with the Rio Moquino, will be excavated and relocated to the open pits.***

There were numerous piles along the Rio Paguate. The following charts their movement based on work units:

Table 6
Movement of Contaminated Soils and Fill Material

Work Unit	Area Moved to North Paguate Pit	Date Closed
2E1N04	Move Protore 2E	Feb-90
2E1N05	Move Protore 10,SP-2-D, SP-1-C	Nov-90
2E1N06	Move Protore 10,SP-2-D, SP-1-C	Nov-90
2E1N07	Move Protore SP-1-A	Nov-90
2E1N11	Move Protore SP-1	Feb-90
2E4N01	Contaminated Soils	Sep-91
2E4N01 A	North Rio Paguate East	Dec-91
2E4N01 B	North Rio Paguate West	Dec-91

Photo B-14, Appendix B, shows the area along the Rio Paguate where the piles once were.

Conclusions - The reclamation actions appear to have been compliant with this item of the ROD.

Recommendations – No further activities are recommended.

2. ***For the Rio Moquino, waste dumps S, T, U, N, and N2 will be pulled back 50 feet from the centerline of the stream channel. The toes of these dumps will be armored with rip-rap.***

A memorandum dated April 23, 1991 from J.H Olsen, Jr. to Governor Harry Early (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)* documented POL Council approved design changes and recommended forwarding descriptions of changes to the BIA for approval. A signed copy of the approvals and authorizations was not found. One of the changes was to revise the approach for erosion control along the Rio Moquino. The following is the relevant excerpt from that memorandum (pg. 1, ¶ 3).

"SPECIAL CASE DESIGN NO. 1-RIO MOQUINO: This case involves removing any potentially contaminated material within the Rio Moquino area which could erode downstream. It eliminates the need for the re-channelization and heavy erosion control structures in the first design. A bench will be excavated on the west side dump and appropriate erosion controls will be placed as needed. Hydraulic analysis on the existing channel was performed by Weston Engineering as a basis for determining the action taken. Estimated cost is now $1,400,000 compared to the $1,900,000 in the Jacob's estimate."

The following work units cover the movement of the waste and protore piles along the Rio Moquino above the confluence and the Rio Moquino Erosion Control activities:

Table 7
Movement of Waste and Protore Piles Along the Rio Moquino

Work Unit	Area Moved to North Paguate Pit	Date Closed
2E1N02	Move Protore SP-2C	Sep 91
2E1N03	Move Protore 1 B	Nov-90
2E1N010	Move Waste Pile N	Sep 91
2E6N01 A	Pull Back Contaminated Soil Along Rio Paguate	Nov 94

Photos B-15, 16, and 17, Appendix B, show an archived POL photo from approximately 1994 and two 2006 photos of the Erosion Control along the Rio Moquino.

Conclusions - The material appears to have been relocated or pulled back and armored to the specifications of the ROD and the approved changes. The Landmark/Weston Design, (Landmark Reclamation/Weston, "*Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Draft Special Case Designs*", December 1990) with the approved changes, reduced the rigor of the original erosion protection. The approved design was implemented and the letter of the ROD was met. However, the intent of the ROD is not being met because the design was inadequate to prevent erosion of the banks below the toes of the waste piles.

However, significant erosion has taken place in the past 12 years. If erosion continues at the same rate, there is serious potential for exposure of waste or contaminated soil at the toes of Piles S, T, U, N, and N2. In view of the fact that a less rigorous redesign was approved after the ROD, this unexpected erosion is a problem. If the erosion continues, waste material will be exposed creating the potential risk of human and wildlife exposure to unknown hazards, and a threat to the water quality of the Rio Moquino.

Recommendations - A more thorough inspection and hydraulic analysis and erosion study needs to be performed to determine if additional erosion protection is needed along the Rio Moquino above the confluence. A control structure on the Rio Moquino above the Pueblo of Laguna section may also be considered.

3. ***A concrete drop structure will be constructed across the Rio Moquino approximately 400 feet above the confluence with the Rio Paguate.***

There was a six-foot drop at the main Jackpile haul road crossing of the Rio Moquino. A control structure was planned and included in the ROD. A flood occurred in July 1993 and is documented in Project Status Report No. 48, July 1993. There were no photos of the roadway crossing washout presented in that monthly report. The local USGS gauging station was washed out with the flood so the precise size of the storm was not recorded. It is estimated to have been greater than a 100-year flood. The flood washed out the crossing and the route was abandoned. This is documented in Project Status Report No. 48. The access route to the Jackpile site was re-routed to a low water crossing southwest of the Jackpile, which is currently used. Since the old crossing is no longer used there is no need to place a drop structure.

Photo B-18, Appendix B, is a 2006 OAS photo of the Rio Moquino at the former road crossing. Aerial photographs were reviewed pre flooding (1992) and post flooding (1993), however, the solution was insufficient to illuminate that area.

Conclusions - Due to the flash flood event that caused the stream crossing to be relocated and changed the stream flow conditions, the Rio Moquino drop structure was no longer needed. Therefore, compliance with this ROD requirement is not applicable.

Recommendations – No further activities are recommended.

B. ***Arroyo Headcutting:***

Arroyos south of waste dumps I, Y, and Y2, and the arroyo west of waste dumps FD-1 and FD-3 will be armored as shown in the FEIS Appendix A (Figure A-13). Other headcuts encountered during reclamation will also be stabilized by armoring.

The arroyo headcutting west of the waste dumps ended when the sandstone outcropping was encountered at the surface. It was determined that armoring was not needed to prevent further headcutting. An OAS 2006 Photo B-19, Appendix B, shows the sandstone outcropping. There has been no appreciable headcutting in the area since the outcrop became exposed. Headcutting areas are shown on the Base Map.

Conclusions - Based on OAS field inspection documented in the photograph, field conditions changed when the headcutting encountered a natural outcropping of sandstone. The sandstone impedes further headcutting negating the need for armoring. Therefore, this is considered a non-substantive variance from the ROD requirements.

Recommendations – No further activities are recommended at this time.

C. ***Blocked Drainages:***

1. ***Waste dump J and protore stockpiles SP-17BC and SP-6-B will be removed to unblock ephemeral drainage on the south side of the mine site.***

Blocked drainages are shown on Exhibits 1 and 2.

Waste dump J was found to not be blocking the stream. Distance made it uneconomical to transport the waste into the Jackpile pit, therefore, it was not removed. It was sloped, covered and seeded.

Protore Pile SP-6-B move is documented in Project Status Report No. 43, February 1992. However, SP 17BC was not mentioned in the Jackpile Protore report attached to Project Status Report No. 43. An aerial photo dated 8-21-03 indicates that material has been removed from both those protore areas and revegetation is taking place. This can be seen in the areas just to the east of the remaining waste dump J. The aerial photo also supports the statement that waste dump J does NOT block any drainage.

Photo B-20, Appendix B, shows waste dump J in the background and the level ground in the front formerly contained the protore piles SP-6B and SP-17BC.

Conclusions - While the letter of the ROD was not met with regard to the movement of waste dump J, closing it in place appears to meet the intent of the ROD and no problems have arisen to date by this action. However, this area could be a physical hazard in that livestock could become entangled in the submerged fence, or stuck in the mud.

Recommendations – Because the land grant property is in close proximity to the Pueblo of Laguna, an effort should be made to jointly maintain the existing dirt banks and monitor the ponded water to determine if it presents any chemical or radiological hazard for domestic animals or wildlife. After the evaluation has been completed, a long-term solution may be devised.

2. ***Two blocked drainages north of FD-1 and F dumps will remain blocked. The remainder of the minesite, excluding open pits, will drain to Rios Paguate and Moquino.***

The blockages to the north of FD-1 and F were left and subsequently a semi-permanent ponded area has formed north of the Jackpile Pit. An OAS 2006 photo B-21, Appendix B shows the large ponded area.

M. Sarracino reports the pond stretches onto the Trust Lands to the north. Cattle from these lands have watered at this pond and several have drowned, leading to damage claims against the tribe.

There are no other ponded areas outside the pit on the Indian lands, so the remaining areas appear to be draining to the Rio Paguate and Rio Moquino, as planned.

Conclusions - The letter of the ROD has been met. However, an unforeseen circumstance has arisen in that the ponded water appears to be at least a physical hazard, and potentially a chemical and radiation hazard, for the neighboring landowners and the cattle that are grazed on that land.

Recommendations - Since grazing livestock have access to the ponded water, POL should sample the water to determine if it presents any chemical or radiological threat to the grazing animals. Additionally, the pond has been in the past, a physical hazard for the domestic animals. The area needs to be evaluated and a long-term solution devised.

6. *SURFACE FACILITIES/STRUCTURES*

A. *Lease No. 1:*

All buildings on Lease No. 1 (Jackpile lease) will be demolished and removed except for the Geology building, miner training center and buildings at the old shop and the open pit offices. The land surface (except pit highwalls and natural outcrops) will be cleared of radiological material (e.g., Jackpile Sandstone) until gamma readings of twice background, or less, are achieved. These areas will then be graded and seeded.

Site inspection indicated all structures were removed and the areas appear to be re-vegetated successfully. Although the ROD noted that some structures were to remain at the site, deterioration and safety issues required dismantling of these structures.

Radiological Clearance is discussed in Section 10-Monitoring of this report.

Table 8
Lease No. 1 - Facilities/Structures Status

Jackpile Lease No. 1	Proposed	Status
Geology Building at Housing Area	Leave in Place	Deterioration and Safety Issues required dismantling. Panels stored at LCC shop area
Miner Training Center at Housing Area	Leave in Place	Deterioration and Safety Issues required dismantling.
Old Shop Buildings across Highway	Leave in Place	Deterioration and Safety Issues required dismantling.
Open Pit Offices	Leave in Place	Asbestos and Safety Issues required dismantling.
All other buildings	Demolish	Deterioration and Safety Issues required dismantling.

The information in the Status column above was provided to OAS by M. Sarracino, January 30, 2007. He further stated that all areas were disked and seeded. Some of this can be substantiated in the memorandum, dated April 23, 1991 from POL Project Manager J.H. Olsen, Jr. to Governor Harry Early recommending approval by the council of Special Cases. (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)*

B. ***Lease No. 4:***

All structures and facilities associated with the P-10 mine and new shop, including all buildings, roads, parking lots, sewage systems, power lines and poles, will be left in place. All operational and maintenance equipment, including tools, machinery, and supplies will be removed. All permanent structures and land surfaces (except pit highwalls and natural outcrops) will be cleared of radiological material until gamma readings of twice background or less are achieved. These areas will then be graded and seeded. Non-salvageable contaminated buildings and materials will be removed to the pits for disposal.

A memorandum dated April 23, 1991 from J.H Olsen, Jr. to Governor Harry Early (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)* documented POL Council approved design changes and recommended forwarding descriptions of changes to the BIA for approval. A signed copy of the approvals and authorizations was not found. Some of the changes related to deviations from facilities demolition plan. The following is the relevant excerpt from that memorandum. (pg. 4, ¶ 1)

" d) REMOVAL OF REMAINING BUILDINGS

Two buildings at the P-10 site need to be dismantled so the required backfill and site cleanup around the decline can be completed. The old welding shop also needs to be dismantled since the sheet metal panels are deteriorating and becoming a potential hazard. The old Geology Building and the P-10 compressor building have already been dismantled and the materials stored in the LCC Shop Yard. Unless other direction is received by May 31, 1991, the buildings will be dismantled by the LCC Surface Crew and the materials placed in the LCC Shop Yard for future use. Prior to release of these materials, however, a radiological survey would need to be performed by Eberline in accordance with the Environmental Monitoring requirements."

Site inspection indicated all structures were removed and the areas appear to be re-vegetated successfully.

Table 9
Lease No. 4 – Facilities/Structures Status

P-10 Lease No. 4	Proposed	Status
Buildings	Leave in Place	Deterioration and Safety Issues required dismantling.
Roads	Leave in Place	Left in Place
Parking Lots	Leave in Place	Abandoned, graded and seeded
Sewage Systems	Leave in Place	Abandoned Pond, graded and seeded
Power lines & Poles	Leave in Place	Dismantled due to aesthetics and safety issues

Information presented in the Status column above was provided to OAS by M. Sarracino, January 30, 2007. He further stated that all areas were disked and seeded. Some of this can be substantiated in the memorandum, dated April 23, 1991 from POL Project Manager J.H. Olsen, Jr. to Governor Harry Early recommending approval by the council of Special Case Designs. (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)*

Table 10
New Shops – Facilities/Structures Status

New Shops	Proposed	Status
Buildings	Leave in Place	Left in Place, Active
Roads	Leave in Place	Left in Place, Active
Parking Lots	Leave in Place	Left in Place, Active
Sewage Systems	Leave in Place	Left in Place, Active
Power lines & Poles	Leave in Place	Left in Place, Active

C. *Access Routes:*

The four major roads within the mine site will be cleared of radiological material and left after reclamation for post mining use. These access routes include: 1) the access road from P-10 and the new shop area to State Highway 279; 2) the main road through the mine; 3) the road that passes between the housing area and North Oak Canyon Mesa and then proceeds to P-10; and, 4) road to Jackpile well No. 4. All other roads (except on lease No. 4) will be removed. These areas will then be graded and seeded.

Site inspection revealed the following status of the roadways covered by the ROD. Exhibits 1 and 2 show the locations of these routes.

Table 11
Access Routes Status

Roads	Proposed	Status
P10 & New Shops to Hwy 279	Leave in Place	Active, maintained dirt road
Main Road Through Mine	Leave in Place	Active, maintained dirt road
Housing and Oak Canyon to P-10,	Leave in Place	Abandoned, other access way
Road to Jackpile well No.4	Leave in Place	Active, maintained dirt road
All others except Lease No. 4	Grade & Seed	Abandoned, no maintenance, no grading or seeding.

The information in the *Status* column above was provided to OAS by M. Sarracino, on January 30, 2007. Photos B-22 and B-23, Appendix B, respectively show the P-10 Well features and the New Shop Well features.

D. ***Water Wells:***

Jackpile well No. 4, the P-10 well, the new shop well, the old shop well, and the 3 wells with associated sheltering structures (near the housing area) will be left. The pumps, riser pipe, wiring, and water storage tanks will be removed. Wells established for future monitoring purposes will also be left. All wells will be capped to prevent dust, soil, and other contaminants from entering the well casing.

Table 12
Water Wells Status

Water Supply	Well Pipe	Pump	Riser	Wiring	Tanks
Jackpile No.4	capped	removed	removed	removed	removed
P-10	capped	removed	remains	remains	remains
New Shop	active	active	active	active	active
Housing area (3 wells)	closed	removed	removed	removed	removed

E. ***Rail Spur:***

The rail spur will be left intact. The rail spur must be cleared of radiological material until gamma readings of twice background or less are achieved. The Quirk loading dock will be demolished and hauled to the pits.

Based on OAS site inspections, the Quirk Loading Dock was demolished and the rail spur remains.

Conclusions - Based on memoranda, discussions with M. Sarracino and an OAS field inspection, some features shown which were anticipated to be kept or salvaged were found to be of very poor condition. While not in strict compliance with the ROD, the demolition and disposal of additional facilities in no way impairs the environmental integrity of the project. Therefore, this is considered a non-substantive variance from ROD requirements.

Recommendations – No further activities are recommended.

7. *DRILL HOLES*

All drill holes will be plugged according to the State Engineer's requirements. A 5-foot surface concrete plug will also be placed in each hole. Any cased holes will have the casing cut off at the surface. In addition, areas around drill holes will be seeded. Any exploration roads not wanted by the Pueblo will be reclaimed.

Project Status Report No. 4, November 1989, reports that Work Item 2S1S05 is to plug drill holes. However, the report states *"There is no work to be done in this package. The CMC inspector has gone over the entire area where the drill holes were, and did not find a single one open."*

Conclusions - It is unclear what happened to the drill holes. No drill holes were found by CSM and that work unit was closed out on approval of all three parties. Therefore, this is considered a non-substantive variance from the ROD requirements.

Recommendations – No further activities are recommended at this time.

8. *UNDERGROUND MODIFICATIONS*

A. *Ventilation Holes:*

Vent holes will be backfilled with waste material (Dakota Sandstone and Mancos shale) to within six feet of surface. Surface casing will be removed, steel support pins installed in walls of vent holes, and sealed with a six-foot concrete plug from backfill to surface. Areas around vent holes will be contoured and seeded.

Project Status Report No. 2, September 1989 reports ongoing activity with respect to locating vent holes. Project Status Report No. 4, November 1989 reports all the vent holes have been closed under Work Unit 2S1S04 except for one in the Jackpile Pit. Project Status Report No. 32, March 1992 indicates the closeout of Work Unit 2S1S04, therefore, it is assumed that the Jackpile vent hole was closed. There are no specifics with regard to the actual physical closures methods used on the vent holes.

Conclusions - It is unclear how the vent holes were closed and there are no records of how they were closed. Monthly reports indicated that the vent holes were being closed, and the work unit was closed out on approval of all three parties. Therefore, this is considered in compliance with the ROD requirements.

Recommendations – No further activities are recommended at this time.

B. *Adits and Declines:*

A concrete bulkhead will be constructed approximately 680 feet below the portal of P-10 decline. The decline will be backfilled from bulkhead to ground surface with Dakota Sandstone and Mancos shale. Sufficient material will be placed over the portal to allow for compaction and settling. The ground surface above the buried portal will be sloped and then top-dressed and seeded. The Alpine mine entry will be bulkheaded and backfilled. Mine entries not previously plugged by backfilling will be covered. Additionally, the H-1 mine adits will be bulkheaded and backfilled and the adits at the P-13 and NJ-45 mines will be backfilled.

Exhibits 1 and 2 present the locations of these mine features.

Although the details of the closures are unknown, the closures appear to have been successful. The general site inspection of areas of the former underground features revealed no evidence of underground mining accesses, no evidence of subsidence, and in general, the areas were indistinguishable from surrounding areas, indicating successful revegetation. The following table summarizes the various entrances and the relevant work unit and closure date when available.

Table 13
Adits and Declines Status

ADITS	Status / Closure Means	Work Unit and Progress Status Reports	Closure Date
P-10	Bulkheaded and Backfilled, Checked for subsidence	2S1S02 Redesign – Project Status Report No. 16 Activity – Project Status Reports No. 30 & 31	March 1992
Alpine	Backfilled and Checked for subsidence	No Specific Work Unit	---
H-1	Backfilled and Checked for subsidence	2S1S03 Closure – Project Status Report No. 28	November 1990
P-13	Backfilled and Checked for subsidence	2S1S01 Closure – Project Status Report No. 29	December 1991

ADITS	Status / Closure Means	Work Unit and Progress Status Reports	Closure Date
NJ-45	Backfilled and Checked for subsidence	No Specific Work Unit	---
P 2/3 Adit	Backfilled and Checked for subsidence	2S1N01	March 1990

The information in the Status column above was provided to OAS by M. Sarracino, January 30, 2007.

Correspondence from the BIA to Governor Lucero, dated December 20, 1990, contains as an attachment a redesign proposed by Landmark Reclamation entitled "Report of Investigation of P-10 Design". Based on the content of the correspondence and attached memorandum, it appears that the new design was adopted by the project team (US Department of the Interior, Bureau of Indian Affairs, Correspondence to Governor Conrad W. Lucero, with attachments including Landmark Reclamation, *"Report of Investigation of the P-10 Decline – Jackpile Project"* (dtd July 30, 1990), December 20, 1990).

Conclusions - It is unclear how the mine entries were closed. But the work units were closed out on approval of all three parties. Because all three parties approved an alternate closure method, it is presumed that the intent of the ROD was met. However, the potential for subsidence may still exist.

Recommendations - Continue to monitor the P-10 and P 2/3 areas for subsidence. Closure methods apparently presented some potential for a "controlled accident", as was stated in the Landmark Reclamation report referenced above.

9. *REVEGETATION METHODS*

A. *Top Dressing:*

Following final sloping and grading, pit bottoms will be top dressed with 24 inches, waste dumps with 18 inches, and all other areas within the minesite with 12 inches of material composed primarily of Tres Hermanos Sandstone (stockpiles at three locations within the minesite). In order to meet top dressing volume requirements for the northern portion of the minesite, additional material may be obtained from a topsoil borrow area in the Rio Moquino floodplain comprising 44 acres. For the southern portion of the minesite, additional topsoil borrow material located east of J and H dumps may be needed. Following topsoil removal, disturbed borrow areas will be contoured, fertilized, seeded, and mulched.

Exhibit 2 shows the topsoil pile locations. Section 3 discusses the waste dumps and their sloping, contouring and cover depths. Verification of top soil depths is also presented in Section 3, Table 4.

B. *Surface Preparation:*

After applying top dressing, areas to be planted will be fertilized, followed by disking to a depth of 8 inches and then contour furrowing.

A memorandum dated April 23, 1991 from J.H Olsen, Jr. to Governor Harry Early (*"Pueblo of Laguna Council, Reclamation Project Issues", April 23, 1991)* documented POL Council approved design changes and recommended forwarding descriptions of changes to the BIA for approval. A signed copy of the approvals and authorizations was not found. One of the changes was to revise the approach for top dressing and revegetation. The following is the relevant excerpt from that memorandum. (pg. 3, ¶ 1)

"TOP DRESSING AND REVEGETATION SPECIFICATIONS: This section specifies the disking, soil placement, seeding, mulching and crimping operations to be used. Following soil placement, the areas will be left fallow until after the typical rainy season so moisture can be re-established in the seedbed. A schedule of activities and the "time window" available to perform them was developed to help the construction activities be coordinated to take advantage of these aspects. Seed mixtures, application rates, and estimated costs are also included. Seeds types to be used include grama grasses, fourwing saltbush, sweetclover, Indian ricegrass, bluestem, sacaton, and others are recommended. Discing will be done to help bind the shale to the topsoil cover. Disking at 45 degrees to the slope will enhance this binding capacity. Seeding will be done with hydroseeding equipment but use of seed drilling equipment on the flat areas is optional and acceptable. Final crimping of mulch and cross-discing on opposing 45 to 60-degree passes on the final slope are also done to help control minor rilling and the formation of water pathways down the slopes. Monitoring procedures are included. An optional specification for tree planting (recommended species and planting procedures) was developed should the POL wish to utilize this technique. Work Packages for the estimated cost can be included in future Annual Operating Plans for Council consideration/action."

C. *Seeding and Seed Mixtures:*

Before seeding operations begin, the entire minesite will be fenced to prevent livestock grazing. In most situations, seed mixtures will be planted with a rangeland drill. Broadcast seeding combined with hydromulching may be used on inaccessible sites or if determined to be more feasible than drilling. For both methods, the seed mixture will consist mainly of native plant species possessing qualities compatible with post grazing use and adapted to the local environment (Tables 3-10 and 3-11; FEIS). Following drill seeding, straw

mulch will be applied at about 2 tons per acre, and crimped into place with a notched disk.

There is some seed preparation and seeding that is documented in the "*Jackpile Project Final Design Recommendations for BIA Approval*", May 9, 1990. (pg. 1, ¶ 1 & 5):

"1) *Previously-reclaimed areas will be left in their current condition except where minor remedial work will be required to repair small rills or gullies. Re-seeding of bare spots on slopes will be done using "hydro-seeding" and mulching techniques. Any remedial work will be done so as to minimize any adverse impact on existing vegetation or other stabilizing features. Re-aligning of drainage paths will be done.*

5) *Hydroseeding is the preferred method since recent reclamation experience on 3:1 slopes shows that use of seed drills and equipment to crimp the mulch actually cause more erosive pathways. Page 7 of the ROD allows for a more "feasible" technique than seed drilling, if available."*

D. ***Revegetation Success:***

Using the Community Structure Analysis (CSA) or comparable method, plant establishment will be considered successful when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding). Livestock grazing will be prevented until 90 percent comparability values are met. At the end of the 10-year monitoring period, if an unsuccessful trend is shown, retreatment may be necessary to achieve success criteria. In the pit bottoms, vegetation will be sampled annually for radionuclides and heavy metal uptake.

As the Jacobs Environmental Monitoring Plan states, revegetation of the site is a critical requirement for stabilizing the disturbed area against erosion and returning the site to productive use. It designated short term monitoring to determine that seeds have germinated and seedlings are growing appropriately and so that corrective measures can be taken to assure success and long term monitoring to meet the ROD. There are references to visual vegetation inspections by "*Ed Kelley, Ph.D. (revegetation consultant)*" in Project Status Reports (Reports No. 43, Feb 1993 and No. 51, October 1993). The ROD requirements are to compare waste pile and pit bottom revegetation against reference sites and to cease monitoring after the revegetated areas meet 90% of the reference site (for selected parameters) but no sooner than 10 years. Four studies were performed:

1) October 1990 (Landmark/Weston 1991) - Landmark Reclamation/Weston, *"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Soils and Vegetation Evaluation for Final Reclamation"*, Final, April 1991.
2) September/October 1996 (Munk and Boden 1996) - Munk, Lewis P. and Boden, Paul, Soils and Biogeochemistry, *"Interim Reclamation Success Analysis, North and South Paguate Open Pits, Jackpile-Paguate Uranium Mine"*, December 1996
3) USDA Natural Resources Conservation Service, 1998 Paguate-Jackpile Mine 1998 Vegetative Inventory [Production Surveys], 1998
4) USDA, Natural Resources Conservation Service, Vegetation Inventory, Production Surveys, August 16, 2000.
5) OA Systems Corporation, *Jackpile-Paguate Uranium Mine Record of Decision Compliance Assessment*, 2007

Table 14
Revegetation Success Sampling Requirements Comparison

	EIS Table 1-5	ROD	Jacobs Environmental Monitoring Plan	Actual
Sampling Points	Transects on waste dumps, pit bottoms and off-site reference areas	Items 9D and 12. Same as EIS	Same as ROD & EIS	1) Early reclaimed mined areas and ref sites (Landmark/Weston 1991) 2) NP and SP pit areas and two reference areas (Munk and Boden 1996) 3) Pit Bottoms only, reference areas not used (NRCS 1998, 2000, 2006)
Frequency	Annually			1) Once in 1990 during reclamation 2) Once in 1996 within NP and SP only, three years after seeding. 3) Three times after reclamation completion

	EIS Table 1-5	ROD	Jacobs Environmental Monitoring Plan	Actual
Parameters	Density, Frequency, foliar cover, basal cover, and Production			1) All ROD Parameters 2) All ROD Parameters 3) Production Sampling, plus qualitative (wind erosion, water erosion, soil crust, plant vigor, seedlings and seed reproduction) plus qualitative assessment of rangeland health using NRCS rating categories.
Duration	CSA = 90% but no sooner than 10 years following reclamation			No regular sampling or duration. The 90% target is not being achieved.

The earlier vegetation studies by Landmark/Weston (1991) and Munk and Boden (1996) followed the procedures and parameter tests laid out by the ROD, but were conducted during and at the end of reclamation and not in the post closure period. During this prolonged study period (1989 through 2006), reference sites and their use as comparisons for successful revegetation evaluations were replaced by other methods. This is reflected in the 1996 Study (Munk and Boden) where they stated that *"the use of reference areas as a reclamation standard is complicated by the lack of a model reference with ideal site characteristics"* and that *"that the reclamation success is obscured by these simple single parameter statistical comparison because of the differences in the vegetative composition among the reclaimed and reference areas."* In subsequent studies conducted by the NRCS and Cedar Creek other evaluation criteria evolved, as discussed below.

Discussion - The three monitoring reports in 1991, 1996, and 2006 consistently determined that vegetation on the reclaimed mine areas can be considered successful in meeting the primary goals of landscape stability, productivity, and good to excellent plant communities.

- The1991 Landmark/Weston report recommended that the vegetation criteria be developed based on acceptable values rather than specific reference sites. Using these criteria, *"All of the reclaimed sites except one (vegetation survey site V-4) could be released for post-reclamation land uses without further monitoring."*

- The 1996 Munk and Boden report stated that, *"In general, reclamation in the pit bottoms can be considered successful in meeting the goals of landscape stability, productivity, and containment of the protore."* The reclaimed areas did not meet the strict numerical standards of the ROD requirements, but had vigorous and productive plant communities with desirable perennial grasses and shrubs.
- In the 2006 monitoring report (Cedar Creek 2006), in addition to assessing cover and productivity, followed suggested protocol based on NRCS methods for evaluating and rating ecological sites for health and stability in Chapter 4 of the National Range and Pasture Handbook for inventorying and monitoring land resources. The sampling and monitoring results compared these naturalized plant communities (on the reclaimed mine site) to the desired plant community based on the reclamation and revegetation techniques (grading, topographic and water control, and seed mix) used on the Jackpile mine. The trends and ecological health of the plant communities, and other physical attributes, showed excellent balance and sustainability of the reclaimed areas for physical structure (topography, soils), hydrology (streams, runoff, watersheds, pools, springs and seeps), and ecology (vegetation, animals, and habitats).

The results of the vegetation monitoring show good to excellent plant communities with foliar cover values of 43-50%; according to Landmark/Weston (1991) regional values are 10.3% to 26.5%, so the cover values far exceed the 90% specified in the ROD; and plant production of 523-1,043 lbs/ac on the reclaimed lands. The trends in vegetation are stable for plant diversity and health. The reclaimed mine areas can be considered successfully revegetated based on the available monitoring data. The reclaimed mine has stable and self-sustaining diverse ecosystems with very good to excellent vegetative cover and productivity of desirable plant species, and good habitat for local wildlife. There are no comparable reference sites for determining the success standards of these ecosystems as required by the ROD. The conclusions of the monitoring reports were that the mine has successful vegetation based on production and other criteria of stability and sustainability.

Conclusions - The Jackpile Reclamation Project post reclamation vegetation monitoring program deviated from the requirement of the Record of Decisions. This was due to evolution in the methodologies developed, accepted and routinely accepted in the scientific community in determining vegetative success. The monitoring met the intent of the ROD in determining vegetation success, in that the mine was very successfully revegetated based on important vegetation parameters of cover and productivity. The revegetation did not meet the strict numerical standards of the ROD, but had vigorous and productive plant communities with desirable perennial grasses and shrubs. The condition of post-reclamation vegetation is very good to excellent, and the reclaimed mine has stable and self-sustaining diverse ecosystems, and good habitat for local wildlife. Trends in vegetation are stable for plant diversity and health.

Item 9-D of the ROD requires pit bottom vegetation be sampled annually for radiological and heavy metal uptake for a period of ten years. This was not done on a continuous basis during the 10-year period after reclamation was completed. Further discussion is presented in Section 10-Monitoring (f) and (g).

Recommendations - Vegetation uptake should continue to be monitored periodically in the future, especially in the pit bottoms. It has been suggested that monitoring be undertaken the next year and possibly every five years after next year; especially in the pit bottoms and in the North Paguate pit in particular.

10. *MONITORING*

The monitoring period will vary for each parameter. Existing monitoring activities to be continued will include meteorologic sampling, air particulate sampling, radon sampling (ambient), radon exhalation sampling, gamma survey, soil and vegetation sampling, water monitoring, and subsidence. In addition, the monitoring program will be expanded to include: radon daughter levels (working levels) in any remaining mine buildings, and groundwater recovery levels/salt buildup in the open pits. The groundwater monitoring period will be of sufficient duration to determine the stable future water table conditions. Refer to Table I-5 of the FEIS for details of the monitoring plan as described under the Preferred Alternative.

The Jacobs Environmental Monitoring Plan was developed for use during and after reclamation. This Environmental Monitoring Plan was approved October 1989 and implemented by the Pueblo of Laguna. To check for compliance with the ROD, OAS compared the Final EIS Table I-5 to both the Jacobs Environmental Monitoring Plan and the actual data sets provided by the POL.

It was stated in the introduction to the Jacobs Environmental Monitoring Plan that, *"as the Jackpile Project proceeded into the preparations of the final engineering designs and detailed project operating plans, modifications to the monitoring program were developed."* To view specific rationale for changes, the Jacobs Environmental Monitoring Plan should be reviewed. For the most part, the reasons included additional data obtained since the FEIS, technology advancements, closer review of existing data sets led to elimination of some monitoring as unnecessary, the decision to go with an independent party to collect and analyze the samples, and increased participation of the BIA in an oversight role. It is OAS' judgment that the reasons for modifying the FEIS lists appear to be reasonable and justified.

Many of the monitoring details were found in other documents and evolved over time. To address monitoring requirements, OAS broke the requirements out and addressed general areas of Water Quality, Soils and Plant Uptake, Vegetation Success and Radon. Since the data had not been organized, reviewed, QC checked or evaluated, OAS attempted to do this to some degree and has included individual reports in the Appendices of this document.

a. Meteorologic

The Jacobs Environmental Monitoring Report stated that the wind and precipitation data would be useful in determining when to conduct blasting operations, calculating radiation health impacts, determining irrigation needs in revegetation areas, and determining if operations should be stopped because of excessive dust.

There were some references to the purchase of a weather station in a Project Status Report and remnants of a weather station are near the old housing area. However, no data for weather monitoring was found.

Table 15
Meteorologic Monitoring Requirements Comparison

	EIS Table 1-5	ROD	Jacobs Environmental Monitoring Plan	Actual
Sampling Points	3	Item 10: Per EIS Table 1-5	One Site Location near the center of the designated site.	No Records Found
Frequency	Continuously		Continuously	
Parameters	Wind Speed and Direction		Wind Speed & Direction, temperature, precipitation,	
Duration	A minimum of three years after reclamation		During Reclamation and 3 years after	

The lack of meteorological monitoring data represents **non-compliance** with the ROD. However, the lack of data has no real impact on post closure health and the environment risk, since the disturbed areas have revegetated well and there is no risk posed from blowing dust. Consequently, failure to comply with this requirement is probably not a significant variance.

Conclusions - Meteorologic monitoring was reportedly conducted during reclamation. There is, however, no data for monitoring conducted during that time. Meteorologic monitoring data was collected during reclamation as was appropriate. However, recurring data collection equipment problems resulted in discontinuous data collecting during the post-reclamation period. At least two different monitoring equipment suppliers were tried, but the power supply problems and problems with livestock destroying the equipment continued.

Recommendations – No further activities are recommended.

b. Air Particulates

Table 16 below presents the air particulates monitoring requirements as proposed in the EIS, ROD and Jacobs Environmental Monitoring Plan compared to the actual monitoring that was performed. The EIS proposed separate requirements for monitoring radiological and non-radiological particulates. The ROD and Jacobs requirements, and the actual monitoring that was performed, combined the radiological and non-radiological parameters as shown in the table. The table also shows the differences that were proposed in the number of sampling points and the duration of the monitoring.

Table 16
Air Particulate Monitoring Requirements Comparison

	EIS Table 1-5	**ROD**	**Jacobs Environmental Monitoring Plan**	**Actual**
Sampling Points	4	5	5	5
Frequency	Monthly	Monthly	Continuous	Continuous
Parameters	U (natural), Ra-226, Po-210, Th-230, Total Suspended Particulates (TSP)	U (natural), Ra-226, Po-210, Th-230, Total Suspended Particulates (TSP)	U (natural), Ra-226, Po-210, Th-230, Total Suspended Particulates (TSP)	U (natural), Ra-226, Po-210, Th-230, Total Suspended Particulates (TSP)
Duration	In perpetuity	During reclamation & a minimum of 3 years after	During construction until average levels ≤ 2 times background for 2 successive quarters; and after reclamation, one year & not more than 3 years	Requirement Phased-out

In Section 3.3 of the Jacobs 1989 report, it was stated that "concentrations of uranium (U-238), thorium (Th-230) and radium (Ra-226) were routinely monitored during mining operations and the reported results were within the standards of the NRC (10 CFR Part 20)." Because the reclamation activities were expected to produce less dust than the mining operations, it was anticipated that the radioactive particle concentrations would be very low. During the reclamation operations the results of continuous sampling indicated levels of 0.5 of background to two times background for at least two successive quarters. As the cover was being placed, the levels gradually declined. When the reclamation was completed the levels were consistently at background levels or less than background. Based on those results, the BIA Contracting Officer (CO) and Pueblo of Laguna reportedly agreed to discontinue the particulate sampling as allowed for in Section 5.4 of the 1992 Post Reclamation Long-Term Monitoring Program "Phase-Out of Reporting Requirements". That section allows the requirement to be phased out if the BIA CO agrees that it has been adequately demonstrated that the goals and objectives of the monitoring function have been met.

Conclusions – The BIA Contracting Officer (CO) and Pueblo of Laguna reportedly agreed that it had been adequately demonstrated that the goals and objectives of the monitoring function had been met and agreed to discontinue the particulate sampling.

Recommendations – No further activities are recommended.

c. Ambient Radon

The EIS requirement for monitoring of radon gas is compared to the ROD, Jacobs Environmental Monitoring Plan, and the actual monitoring that was performed, and is presented below in Table 17.

Table 17
Radon Gas Monitoring Requirements Comparison

	EIS Table 1-5	ROD	Jacobs Environmental Monitoring Plan	Actual
Sampling Points	5		5 perimeter sites, including one between Paguate and the mine, 5 sites within the mine, 2 sites in Paguate, and 3 sites in onsite buildings.	
Frequency	Monthly	Item 10: Per EIS Table 1-5	Continuous after construction <3pCi/L for 4 quarters, 2 location in N.Paguate pits, 3 locations outside N.Paguate pits, 2 locations in S.Paguate pits, 4 locations outside S.Paguate pits, 2 locations in Jackpile pits, 4 locations outside Jackpile pits, and 2 location in Paguate	Requirement was waived because measure-ments were consistently below the limit of 3.5 pCi/L set by the ROD
Parameters	Rn-222(pCi/L)		Rn-222(pCi/L)	
Duration	Minimum of 3 years after Reclamation		4 successive quarters no greater than 3pCi/L above background	

The specified limit for radon gas levels after reclamation was 3 picocuries per liter (3 pCi/L) above the background level of 0.5 pCi/L, for a total limit of 3.5 pCi/L. Radon-222 gas was measured as suggested by the monitoring report (Jacobs 1989). The cups were set up on post three feet above ground at each location, and collected quarterly from April 1990 to May 1997. The monitoring station locations and time were recorded on Radon Test Detector log sheets or field forms, and the results listed on Radon Measurement Data sheets and Monitoring Reports for each quarterly testing period. The complete radon-222 survey results were tabulated and reported in the 1996 Annual Report for the Jackpile Reclamation Project. Measurements are reported in picocuries per liter (pCi/L).

Conclusions - All recorded radon gas measurements were consistently below the limit of 3.5 pCi/L set by the ROD. Because of the consistently low measurements it was mutually agreed to phase out this requirement.

Recommendations – No further activities are recommended.

d. Radon Daughter Levels

No records of radon daughter monitoring in remaining mine buildings was located. It is not expected, but if any of the remaining mine buildings have residual Uranium series contaminants (U, Ra 226) and the air in the buildings is relatively stale, monitoring is advised prior to extended occupancy.

Conclusions – No records of radon daughter level monitoring in remaining mine buildings were located. A radon daughter limit of 0.03WL working level was the specified threshold for this parameter. This is ***potentially non-compliant*** with the ROD. However, the buildings were reportedly razed at the start of reclamation. Therefore, compliance could not have been conducted or expected.

Recommendations – It is not expected, but if any of the remaining mine buildings have residual Uranium series contaminants (U, Ra 226) and the air in the buildings is relatively stale, monitoring is advised prior to extended occupancy.

e. Radon Exhalation

Radon Exhalation is the rate of Radon-222 emanation at the ground surface. It is a flux measurement of rate over a surface area. The Jacobs Monitoring Plan eliminated the requirement to measure radon flux *"due to difficulty and technical infeasibility of accurately measuring radon flux"*. The correlations of flux to doses of inhaled radon-22 are poor. There was never a flux standard established in the EIS or ROD to compare flux measurements.

Table 18
Radon Exhalation Monitoring Requirements Comparison

<table>
<tr><th></th><th>EIS Table 1-5</th><th>ROD</th><th>Jacobs Environmental Monitoring Plan</th><th>Actual</th></tr>
<tr><td>Sampling Points</td><td>5</td><td rowspan="4">Item 10: Per EIS Table 1-5</td><td rowspan="4">The monitoring of Radon-222 Flux was eliminated due to difficulty and technical feasibility of accurately measuring radon flux. The radon standard for the project was established as a concentration rather than a flux.</td><td rowspan="4">No Monitoring Performed</td></tr>
<tr><td>Frequency</td><td>Monthly</td></tr>
<tr><td>Parameters</td><td>Rn-222</td></tr>
<tr><td>Duration</td><td>Minimum of 3 years after Reclamation</td></tr>
</table>

This monitoring requirement was eliminated by design at the time of monitoring program development, so while the letter of the ROD was not met, the elimination of this monitoring item was authorized when the monitoring program was adopted.

Conclusions - This monitoring requirement was eliminated by design at the time of monitoring program development, so while the letter of the ROD was not met, the elimination of this monitoring item was authorized when the monitoring program was adopted.

Recommendations – No further activities are recommended.

f. Gamma Survey

Table 19 below presents the gamma radiation monitoring requirements as proposed in the EIS, ROD, Jacobs Environmental Monitoring Plans, and the actual monitoring that was performed.

Table 19
Gamma Radiation Monitoring Requirements Comparison

	EIS Table 1-5	ROD	Jacobs Environmental Monitoring Plan	Actual
Sampling Points	Each waste dump and selected reclaimed areas	Each waste dump and selected reclaimed areas	Each waste dump and selected reclaimed areas	Shops, construction buildings, offices, housing area, Paguate townsite, waste dumps & protore stockpile areas, crusher areas, haul and access roads, loading dock & rail spur from Quirk Station north to the project boundary, 3 pits (N.Paguate, S.Paguate & Jackpile during backfilling & covering with shale and topsoil. The final aerial survey was not conducted
Frequency	As Needed	As Needed	As Needed	
Parameters	Ground survey, plus final aerial survey	Ground survey, plus final aerial survey	Ground survey, plus final aerial survey	Ground survey. Final aerial survey not conducted
Duration	Before seeding and once after reclamation is completed	Before seeding and once after reclamation is completed	Before seeding and once after reclamation is completed	Ground survey. Final aerial survey not conducted

The specified limit for gamma radiation levels after reclamation was twice the background level of 14 micro Roentgens per hour (μR/hr) for a total limit of 28 μR/hr.

Gamma radiation was measured using a TMA/Eberline gamma meter held three feet above the ground. The gamma surveys started during construction in 1990. and were concluded in 1993, when placement of the reclamation cover was completed. The required final aerial survey was not conducted. However, the ground survey that was conducted exceeded the requirement and it indicated no exceedance of the established threshold. There are no records of gamma radiation surveys after 1993. The following are the areas surveyed during the period of 1991 to 1993. They were selected based on recommendations from the EIS and monitoring reports.

1. Shops, construction buildings, and offices; housing area; Paguate townsite
2. Waste dumps and protore stockpile areas
3. Crusher areas; haul and access roads
4. Loading dock and rail spur from Quirk Station north to the project boundary (in 1990)
5. Three pits (North Paguate, South Paguate, and Jackpile) during backfilling and covering with shale and topsoil

Gamma radiation was measured using grids (100x100 feet or 200x100 feet) and recorded on field sheets, log and summary analytical sheets, and hand-drawn field maps. Measurements are recorded in micro Roentgens per hour (μR/hr).

Gamma radiation on the mine reclamation areas was reduced by moving protore and surfaces of the contaminated areas into the pits and covering them with shale and topsoil. Waste dumps that had Jackpile Sandstone on the surface were also covered with topsoil. These activities effectively reduced measured gamma radiation to acceptable levels of less than 25 μR/hr on the mine areas up to, and during, 1993. There were no records of post-reclamation monitoring of gamma radiation after completion of reclamation in 1996.

Conclusions – Based on this radiological measurement review, the following conclusions can be drawn:

1. Gamma radiation monitoring levels were consistently below the 28 μR/hr requirement, or lower, and a continuous monitoring program was not warranted.
2. The gamma radiation monitoring requirement stated that a ground survey, plus a final aerial survey, was to be conducted. The monitoring was to be conducted before seeding and after reclamation was completed. Monitoring was conducted before seeding, but the final aerial survey was not performed.

3. It is recommended that a final ground survey, or final aerial survey, be conducted, especially on the access roads, pit bottoms and former protore piles sites to verify that these areas meet the 28 μR/hr requirement.

Recommendations - Based on these conclusions, the following recommendations can be made:

1. Gamma radiation levels should be checked at least one more time to verify that reclaimed areas are meeting the standard of 28 μR/hr.
2. The reclaimed mine can be released from any requirement for radon gas measurements, and should present no hazards for human health.
3. The results of the process and sampling during the current and previous radiation monitoring should be reviewed.
4. Gamma radiation levels on the access roads, pit bottoms and former protore pile sites should be checked at least one more time, and in the future if the topography changes, to verify that those areas meet the 28 μR/hr requirement.

g. Soil

There were three types of soils testing discussed in documents associated with the Jackpile Reclamation: 1) testing for suitability for topsoil that could support revegetation goals, 2) testing of heavy metals and radiological compounds and 3) testing for salt buildup that could reach concentrations toxic to plants.

Table 20
Soils Testing Requirements Comparison

	EIS Table 1-5	ROD	Jacobs Environmental Monitoring Plan	Actual
Sampling Points	One grid per 50 acres on each waste dump and pit bottom	Item 10: EIS Table 1-5 Unspecific	For Salt Buildup NP Pit: 2 east, 2 west SP Pit: 2 east, 2 west Jackpile: 4 locations Half the locations in each pit will be in areas where ponding occurs after large precipitation events and half on well-drained areas. Sample collected from 3 to 9 inches below surface. Sampling points marked with 3 foot steel posts.	1.) For Topsoil Suitability Landmark/Weston (1991) collected 38 samples from 26 locations in the pit areas. 2.) For Potential for Plant Uptake Munk & Boden (1997) collected 12 samples 3.) No Salinity Sampling
Frequency	Once Prior to Seeding		Annually	1.) Once 2.) Once

Parameters	U(natural), RA-226, Th-230, Se, Va, As, Cd, Mo, Pb, Zn		EC of saturated paste extract	1.) pH, EC, saturation %, Ca, Mg, Na, SAR, soil characteristics 2.) As, Cu, Mo, Pb, Se, Zn, Va, Pb-210, Po-210, Ra-226
Duration	Once Prior to Seeding		Begin after backfilling and continue for 10 years	1.) Once 2.) Once

1) Topsoil. The Jacobs Monitoring Report discusses soil testing to determine suitability for topdressing which was part of the reclamation operations and included in the construction specifications. It was not a part of the Long Term Post Closure Monitoring Program discussed in ROD Item 10. There are several reports which contain data on soils for suitability for top dressing: Landmark/Weston (1991), Munk and Boden (1996) and Munk and Boden (1997) [Munk, Lewis P. and Boden, Paul, Soils and Biogeochemistry, "*Potential for Plant Uptake of Heavy Metals and Radionuclides, North and South Paguate Open Pits, Jackpile-Paguate Uranium Mine*", May 1997]. Appropriate topsoil source areas were found.

2) Radiologicals and Heavy Metals. The EIS Table 1-5 presents radiological and heavy metal parameters to be tested in soils from the dumps and pit bottoms, to assess potential for plant uptake. The Munk and Boden (1997) reports that samples were taken at 12 locations within the pits for some radiological and heavy metals compound. The analyses of the soil topdressing, shale cover material, and protore in the pit bottoms indicated that the heavy metals arsenic, copper, lead, molybdenum and zinc occurred at typical levels for natural soils. However, selenium, vanadium radium-226, Pb-210, Po-210 occurred at elevated levels in the Jackpile Sandstone protore. The exposed protore was considered the worst case scenario. All exposed protore within the pits were covered with the agreed upon barrier cover and topsoil depths and thus those elevated concentration should be of no concern. The ROD requirement for monitoring was met.

3) Salt Buildup. The ROD required salinity monitoring in the pits. The Jacobs Monitoring Plan directed the soils in the pits be monitored for salt buildup since a survey of drainages blocked by waste dumps showed the build-up of salts to levels toxic to plants in areas adjacent to the blockage. There were no data found regarding monitoring for salt in soils.

Conclusions – The topsoil, radiological and metals monitoring requirements of the ROD have been met. The salt buildup and impact to grazing has not been met.

Recommendations – The lack of salt monitoring represents ***non-compliance*** with the ROD requirements; however, the presence of well established vegetation would appear to indicate that salt buildup is not occurring. It is recommended that the pit bottom soils be analyzed for salt build up, and in the future if it appears that salt buildup is occurring.

h. Radionuclide and Heavy Metal Uptake into Vegetation

The Jacobs Environmental Monitoring Report reports that early data sets showed that *"vegetation on the disturbed areas is not accumulating heavy metals or radionuclides in concentrations that are toxic to livestock"*, but that it would be prudent to monitor to see if uptake changed with time.

Table 21
Monitoring Requirements for Radionuclide and Heavy Metal Uptake Into Vegetation Comparison

	EIS Table 1-5	ROD	Jacobs Environmental Monitoring Plan	Actual
Sampling Points	Transects on selected reclaimed waste dumps and all pit bottoms	Item 12: EIS Table 1-5, minimum 10 years following reseeding	One location per dump with JSS on outer surface	Pit Bottoms
Frequency	Annually		Annually	2001,2003, 2005, 2006
Parameters	U(natural), RA-226, Po-210, Th-230, Se, V, As, Cu, Cd, Mo, Pb, Zn		Edible Fraction for Ra-226, Po-210, Pb-210, Se, Va, As, Mo, Pb, Cu, Zn	As, Cu, Pb, Mo, Se, V, Zn, Pb-210, Po-210, Ra-226
Duration	A minimum of 10 years following reclamation		Commence one year after reseeding for a minimum of 10 years following reclamation. Increase locations if the trends indicate that toxic levels are being approached.	

The Jacobs Environmental Monitoring Plan presents justification for eliminating some of the compounds contained in the EIS Table 1-5. The report stated *"Thorium-230 does not present a significant ingestion pathway, Uranium has a low plant uptake factor, Pb-210 presents the greatest human exposure"*.

There were four years (2001, 2003, 2005, and 2006) in which vegetation was clipped and analyzed for heavy metals and radionuclides. The data are summarized in the Table 22 below.

Table 22
Summary of Results of the Heavy Metal and Radionuclide Vegetation Uptake Monitoring for the Jackpile Reclamation Project

Year	2001 – 15 Samples			2003 – 10 Samples			2005 – 39 Samples			2006 – 16 Samples		
	Range	ND *	Avg	Range	ND	Avg	Range	ND	Avg	Range	ND	Avg
Metals												
As	0-0.8	13	0.2	-	10	-	0-5.0	10	0.8	0-3.3	12	0.4
Cu	1.1-4.0	0	2.5	1.3-4.7	0	2.4	1.4-3.8	0	2.5	1.9-7.6	0	2.9
Pb	0-1.3	13	0.1	0-1.8	8	0.02	0-4.0	25	0.4	0-2.2	12	0.4
Mo	0-2.1	12	0.2	0-3.7	9	0.4	0-3.3	6	0.4	0-3.1	8	0.5
Se	0-9.4	9	1.5	0-5.3	3	0.9	0-5.3	9	1.4	0.5-42.9	0	6.4
V	0-3.7	9	0.6	0-4.8	7	0.6	0-8.1	28	0.7	0-19.1	13	1.5
Zn	9-47	0	20	8-29	0	15	3-34	0	18	8-25	0	14
Radionuclides												
^{210}Pb	0.1-0.9	0	0.44	0-1.12	1	0.50	0-0.3	14	0.07	0-.87	4	0.28
^{210}Po	0-0.5	5	0.17	.03-.34	0	0.12	0-0.2	2	0.05	.02-1.16	0	0.28
^{226}Ra	0-0.5	5	0.17	0.2-0.5	0	0.38	0-2.1	2	0.72	.002-.51	1	0.19

Results are in mg/Kg (ppm) for metals, and pCi/g (picocuries per gram) for radionuclides.
**ND – number of samples below detection limits*

Metals

Measured uptake concentrations of metals into vegetation were either below, or within, normal ranges for all heavy metals analyzed. As discussed by Munk and Boden (1997), the potential for uptake by most plants is minimal given the soil properties in the pit bottoms. This was confirmed by the four growing seasons (2001 to 2006) of vegetation sampled and analyzed for heavy metals. There was some concern by Munk and Boden (1997) that selenium and vanadium may accumulate on the surface soils and be translocated from the Jackpile Sandstone backfilled and covered in the pit bottoms. However, there was no increasing trend of these two metals measured in the vegetation eleven years after revegetation was complete.

The concentration in one shrub (four-wing saltbush) analyzed for selenium was within a normal high range, and may indicate that this shrub species is a secondary accumulator. This species is a member of the goosefoot family, and is not generally grazed by domestic livestock when other more palatable grass species are available.

Domestic livestock can graze the grass/shrub vegetation in the pit bottoms without toxic effects from heavy metals. Selenium was the only metal found to have the potential for sub acute toxicity on one sample in one shrub species that is generally not browsed by livestock. It is not recommended that heavy metals be monitored in the future based on the sample results to date.

Radionuclides

The concentration levels of radionuclides in the plant samples analyzed were uniformly low with no increasing trends in levels over the four seasons vegetation was sampled. The concentration levels are well below the values that are considered toxic to domestic livestock or wildlife; therefore, radionuclides would not need to be sampled in the future.

Conclusions - The Jackpile Reclamation Project vegetation uptake-monitoring program deviated from the requirement of the ROD in that heavy metals and radionuclides were not measured for ten consecutive years after reclamation was completed. Vegetation had low levels of metal and radionuclide uptake based on sampling and laboratory analysis. It is believed that vegetation growing on the reclaimed mine presents a minimal potential for hazards to domestic livestock or human health due to the low or normal concentrations of metals and radionuclides.

Recommendations - As previously mentioned in ROD Item 9, it has been recommended that uptake monitoring be undertaken next year and possibly on five-year intervals thereafter in the pit bottoms and particularly in the North Paguate pit.

i. Water Quality

OAS reviewed the post-reclamation water quality monitoring and data with the intention of: determining if the post-reclamation water quality monitoring has met the requirements of the ROD, examining the water quality data collected as to its validity and its applicability in assessing long-term risks to people and the environment, defining contaminants of concern and trends of these data, and making recommendations as to future monitoring programs and steps that should be taken to ensure the health and safety of nearby residents. This study is documented in the report "*Jackpile-Paguate Uranium Mine Post-Reclamation Water Quality Review*" presented in Appendix D.

- ***Sampling Points***

Table 23 presents the groundwater monitoring points. The FEIS proposed using 17 existing wells, the Jacobs Environmental Monitoring Plan proposed nine (9) groundwater well locations and formations for completion and six (6) wells to monitor the open pit groundwater, and two (2) or more wells at the discretion of the POL and BIA. According to the Jacobs Environmental Monitoring Plan, the existing wells were old, poorly constructed and documented, not located properly for assessment of long term monitoring of contaminant transport, so in effect unusable. Eight (8) wells were established in accordance with the Jacobs Environmental Monitoring Plan, one deep upgradient well collapsed and was abandoned early in the monitoring period. The two wells to be designated after the monitoring program was initiated were never placed. It is assumed that the 7-well coverage was deemed adequate by POL and BIA. Although the plan called for a downgradient well in the deeper Jackson Sandstone formation, both wells that are downgradient of the pits are completed in the Alluvium (MW-2 and MW-6). Four (4) of the six open pit wells were installed. No wells were installed in the Jackpile Pit. This oversight was corrected in 2007. None of the discretionary wells were installed.

Table 23
Groundwater Monitoring Points

Final EIS Preferred Plan	**Jacobs Environmental Monitoring Plan**		**Actual**	
Well Location	**Well Location**	**Formation for Completion**	**New Wells**	**Variation**
	GROUP A			
17 existing wells (no specific locations indicated) Old wells were not part of the reclamation monitoring program. These were deemed by Jacobs to be deteriorating, of unknown construction materials and configuration.	Southwest of South Paguate Pit (background well)	Jackpile Sandstone	MW-8	This was a deep well that collapsed early in the monitoring program (JSS, Steel, 456 ft.)
	North of North Paguate Pit (background well)	Jackpile Sandstone	MW-1	Upgradient of Paguate Pits (JSS, PVC, 231 ft.)
	North-northeast of Jackpile Pit (background well)	Jackpile Sandstone	MW-7	Upgradient of Jackpile Pit (JSS, PVC, 375 ft.)
	North of the Rio Paguate and west of the Rio Moquino near the confluence			Not Installed
	South of the Rio Paguate and north of the South Paguate Pit	Alluvium	MW-4	Between So. Pit and River (Alluvium, PVC, 50 ft.)
	South of the Jackpile Pit offices and east of the Rio Paguate	Alluvium	MW-3	Between No. Pit and River (Alluvium, PVC, 60 ft.)
	In Oak Canyon adjacent to the designated site boundary	Jackpile Sandstone	MW-5	Downgradient of South Paguate Pit (JSS, PVC, 262 ft.)
	Near the Intersection of the south end of the designated site boundary and the Rio Paguate	Jackpile Sandstone	MW-2	Downgradient of all pits along Rio Moquino (Placed in Alluvium, PVC, 40 ft.)

Final EIS Preferred Plan	Jacobs Environmental Monitoring Plan		Actual	
Well Location	**Well Location**	**Formation for Completion**	**New Wells**	**Variation**
	Near the Intersection of the south end of the designated site boundary and the Rio Paguate	Alluvium	MW-6	Downgradient of all pits along Rio Moquino (Alluvium, PVC, 60 ft.)
	GROUP B			
	In the North Paguate Pit after backfilling	Fill	NP-OP-20E	Unknown completion
	In the North Paguate Pit after backfilling west thumb	Fill	NP-OP-20W	Unknown completion
	In the South Paguate Pit after backfilling SP-20	Fill	SP-OP-35	Unknown completion
	In the main South Paguate Pit after backfilling	Fill	SP-OP-34	Unknown completion
	In the central portion of the Jackpile Pit after backfilling (2 wells)	JP-OP-41 N JP-OP-41 S		Not Installed until April 2007
	GROUP C			
	Two locations to be selected by the Pueblo of Laguna and Department of Interior More wells may be required if the migration of contaminated groundwater off the site is detected by the proposed monitoring wells.			Not Installed

In examining the monitoring wells outside the mine pits, the upgradient wells (MW-1 & MW-7) are screened in the Jackpile Sandstone. The intermediate wells (MW-2, MW-3, & MW-4) are screened in the Alluvium. The down gradient well in Oak Canyon is screened in the Jackpile Sandstone, but the downgradient well positioned to monitor the Jackpile pit and serve as the compliance well near the southern boundary of the site is in the Alluvium. **It is recommended that one of the discretionary wells be placed in the Jackpile Sandstone formation to determine the true impact to that valuable aquifer.**

Table 24 presents the surface water monitoring points. The FEIS proposed using 7 locations (unspecific in Table I-5), the Jacobs Environmental Monitoring Plan proposed six (6) descriptive locations plus each major pond in the open pits. The six (6) locations proposed in the Jacobs Environmental Monitoring Plan were sampled, plus a sampling point at the reservoir/lake. No ponded water in the open pits was sampled until April 2007, when the pond in the North Paguate Pit was sampled and analyzed.

Table 24
Surface Water Monitoring Points

Final EIS Preferred Plan	Jacobs Environmental Monitoring Plan	Actual	
Well Location	**Surface Water Sampling Locations**	**Sampling Points in Closure Monitoring Program**	**Variation**
7 Points (no specific locations indicated)	Upstream on the Rio Moquino	URM	
	Rio Moquino above the confluence	LRM	
	Upstream on the Rio Paguate	URP	
	Rio Paguate above the confluence	LRP	
	Rio Paguate below the confluence	RM	
	Rio Paguate – Ford Crossing	RT	
	Each major pond in the open pits		Not done Lake/Reservoir was designated as a permanent sampling point.

- *Sampling Parameters*

Similarly to the sampling points, some of the sampling parameters and frequency changed (justifiably) between the time of the Final EIS and the development of the Jacobs Environmental Monitoring plan. Table 25 presents the groundwater monitoring parameter comparison.

Table 25
Groundwater Parameters

	Final EIS	Jacobs Environmental Monitoring Plan	Actual	
Duration	**During reclamation and 10 years thereafter**		**During Reclamation 1989-1994[2]**	**Post Reclamation 1995-2006[1]**
Parameters	**Semi-Annually**			
	pH	Annual	Twice per Year	Annual
	EC	Annual		Annual
	Temperature	Annual	Twice per Year	Annual
	Bicarbonate	Once Post Closure	Plus Carbonate	Alk-Carb, Bicarb, Total
	Chloride	Once Post Closure	Twice per Year	Annual

	Final EIS	**Jacobs Environmental Monitoring Plan**	**Actual**	
Duration	**During reclamation and 10 years thereafter**		**During Reclamation 1989-1994[2]**	**Post Reclamation 1995-2006[1]**
	Sulfate	Annual	Twice per Year	Annual
	Sodium	Once Post Closure		Dissolved. Annual
	Silicon dioxide	Once Post Closure		---
	Magnesium	Once Post Closure	Manganese	Dissolved. Annual
	Nitrate	Once Post Closure	Twice per Year	As N, Annual
	Manganese	Once Post Closure	Twice per Year	Dissolved, Annual
	Iron	---	Twice per Year	---
	Uranium (natural)	Annual	Twice per Year	---
	Radium 226	Annual	Twice per Year	---
	Annually: Same as Semi-Annual with:			
	Arsenic	Once Post Closure	Twice per Year	Dissolved. Annual
	Boron	---		---
	[illegible]	[illegible]	Twice per Year	Dissolved. Annual
	[illegible]	[illegible]	Twice per Year	Dissolved, Annual
	[illegible]	Once Post Closure	Twice per Year	Total, Annual
	Cobalt	---		---
Parameters	Chromium	Once Post Closure	Twice per Year	Dissolved, Annual
	Copper	---		---
	Fluoride	Once Post Closure		Annual
	Mercury	Once Post Closure	Twice per Year	Annual
	Molybdenum	Annual	Twice per Year	Dissolved, Annual
	Nitrogen	Nitrites – Once Post Closure		Nitrite, as N, Annually
	Lead	Once Post Closure	Twice per Year	Dissolved. Annual
	Phosphate	Phosphorous – Once Post Closure	Total P	Orthophosphate, as P
	Selenium	Once Post Closure	Twice per Year	Annual
	Vanadium	Annual	Twice per Year	Dissolved, Annual
	Zinc	Once Post Closure	Twice per Year	Dissolved. Annual
	Ra228	---	Twice per Year	Dissolved. Annual
	Water Levels	Annual	Twice per Year	---
		Annual:		
		TDS	Twice per Year	Annual
		Gross Alpha	Twice per Year	---
		Lead 210	Twice per Year	Annual
		Polonium 210	Twice per Year	---
		Once Post Closure		
		Calcium	Twice per Year	Dissolved, Annual
		Silver	Twice per Year	Dissolved. Annual
		Potassium		Dissolved, Annual
		Once Post Closure organic substances:		
		Halogenated volatile organics (EPA Method 601)	8270 Once	Not Found
		Aromatic Volatile organics (EPA Method 602)	All Non Detectable	

	Final EIS	Jacobs Environmental Monitoring Plan	Actual	
Duration	**During reclamation and 10 years thereafter**		**During Reclamation 1989-1994[2]**	**Post Reclamation 1995-2006[1]**
		Base/neutral, acid extractables, and pesticides (EPA Method 625)		

[1] There was some variation year to year, but this represents the most consistent parameter list for the 10-year post closure monitoring effort
[2] Natural Resource Consultants and Testing Laboratory performed the early monitoring through about 1994 and did not analyze Ag,Zn,TSS. Hall Environmental Laboratory performed the later work and ran the list presented

Groundwater monitoring during construction (between 1989 and 1994) consisted of semi-annual monitoring of each of the monitoring wells with the exception MW-8, which was abandoned. Samples were taken in April/May and in November/December. The parameter list consisted of both sets of parameters recommended by the Jacobs Environmental Monitoring Plan. At the time of this review, water level information was only available on a semiannual basis between May 1992 and November 1994.

The post closure monitoring (1995-present) encompassed most of the parameters in the Jacobs Environmental Monitoring Plan and the sampling was performed annually across the board during April/May of each year, providing a redundancy that may not have been needed.

- ***Surface Water***

Table 26
Surface Water Parameters

	Final EIS	Jacobs Environmental Monitoring Plan	Actual	
Duration	**During reclamation and 10 years thereafter**		**During Reclamation 1989-1994[2]**	**Post Reclamation 1995-2006[1]**
	Quarterly			
Parameters	pH	Semi-Annual	Twice per Year	Annual
	EC	Semi-Annual		Annual
	Temperature	Semi-Annual	Twice per Year	Intermittent
	Bicarbonate	Once Post Closure	Plus Carbonate	Annual
	Chloride	Once Post Closure	Twice per Year	Annual
	Sulfate	Semi-Annual	Twice per Year	Annual
	Sodium	Once Post Closure		Annual
	Silicon dioxide	Once Post Closure		Intermittent
	Magnesium	Once Post Closure		Annual
	Nitrate	Once Post Closure	Twice per Year	Annual

	Final EIS	**Jacobs Environmental Monitoring Plan**	**Actual**	
Duration	**During reclamation and 10 years thereafter**		**During Reclamation 1989-1994[2]**	**Post Reclamation 1995-2006[1]**
	Manganese	Once Post Closure	Twice per Year	Annual
	Iron	---	Twice per Year	---
	Uranium (natural)	Semi-Annual	Twice per Year	Annual
	Radium 226	Quarterly	Twice per Year	Intermittent
	Semi-Annually:			
	Arsenic	Once Post Closure	Twice per Year	Annual
	Boron	---		---
	Barium	Once Post Closure	Twice per Year	Annual
	Cadmium	Once Post Closure	Twice per Year	Annual
	Cyanide	Once Post Closure	Twice per Year	Annual
	Cobalt	---		---
Parameters	Chromium	Once Post Closure	Twice per Year	Annual
	Copper	---		---
	Fluoride	Once Post Closure	Twice per Year	Annual
	Mercury	Once Post Closure	Twice per Year	Annual
	Molybdenum	---		Annual
	Nitrogen	Nitrite – Once Post Closure		Annual
	Lead	Once Post Closure	Twice per Year	Annual
	Phosphate	Phosphorous – Once Post Closure	Twice per Year	Annual
	Selenium	Once Post Closure	Twice per Year	Annual
	Vanadium	Semi-Annual	Twice per Year	Annual
	Zinc	Once Post Closure	Twice per Year	Annual
	Ra228	---	Twice per Year	---
	Water Levels	Annual	Twice per Year	Intermittent
		Quarterly:		
		TDS	Twice per Year	Annual
		Gross Alpha	Twice per Year	Intermittent
		Semi-Annual:		
		Lead 210		Intermittent
		Polonium 210	Twice per Year	Intermittent
		Once Post Closure		
		Calcium		Annual
		Silver	Twice per Year	Annual
		Potassium		Annual

Groundwater monitoring during construction (between 1989 and 1994) consisted of semi-annual monitoring of each

A total of seven surface water stations were monitored. These stations correspond to the six (6) river stations in the Plan plus the reservoir/lake. No samples were taken of the ponded water in the open pits until April 2007. Samples were analyzed for both sets of parameters recommended by the Jacobs Environmental Monitoring Plan on a semi-annual basis in April/May and November/December between 1989 and 1994 and annually in April/May between 1995 and the present.

- ***Water Quality Assessment***

The Jacobs Environmental Monitoring Plan required that the Construction Management Company audit laboratory procedures, check for anomalies and proper analytical procedures, compile data on a quarterly basis (submitted to POL and BIA), and prepare annually an Environmental Monitoring Report (containing trend graphs, discussion relative to accepted standards, discussion of anomalies, etc). Only the 1996 annual report was found (*"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Annual Report"*, 1996). The data available to OAS was raw data. The post closure monitoring data was provided electronically predominantly directly by the analytical lab. **There appears to have been no attempt to organize or evaluate the water quality data for the post closure period.** As a result, many parameters were analyzed much more frequently than required (some that were required to be monitored only once were sampled and analyzed for 18 years. sometimes twice a year). Also, opportunities for corrections and modifications to the monitoring plan were missed. Perhaps most importantly, the lab data was not reviewed and some of the lab data is suspect.

For this section, data were evaluated for the Post Closure Period (the last 10 yrs – 1997 through 2006). It should be noted that there are complete data sets for years prior to 1997 but these ten years were considered the most appropriate for this ROD evaluation. In the evaluation of these data sets, there were both positive and negative aspects as presented in Table 27. Overall, there appears to have been no effort to evaluate the data over the last ten years. Data was not organized, laboratory QC/QA was not analyzed, trends were not evaluated, and conclusions were not drawn as to the potential hazards groundwater or surface water posed to human health and the environment.

Table 27
Water Quality Data Condition

Positives	Negatives
• Lab sheets were clear. • Analytical methods were explained. • Duplicate samples and QA/QC samples were identified • Detection limits were for the most part satisfactory • With a few exceptions, all parameters as suggested by the Environmental Monitoring program were analyzed for each year • Samples were collected consistently during the	• Data was not organized. • Neither the laboratory nor the Reclamation Project performed standard quality control and quality assurance procedures. • Data transfer to logical readable tables was time consuming. • It appears that the data was not evaluated on an annual basis to identify trends and concerns.

Positives	Negatives
months of April and May for each year	• No water quality standards were defined in the ROD, Monitoring Plan or EIS. • No wells were installed in the Jackpile Pit • Ponded water in open pits was not sampled • A well was not installed in the Jackpile Sandstone formation near the downgradient boundary • Some of the depth to water measurements in the monitoring wells was not available. • Flow, although not required by the ROD would be helpful in understanding the surface water flow system.

- ***Quality Control and Quality Assurance***

In the evaluation of water quality data, quality control and quality assurance measures taken in the field and in the laboratory are of primary concern. The Jacobs Environmental Monitoring Plan goes into detail on how samples are to be collected in the field and use of duplicate samples to ensure that the laboratory analyses are acceptable. OAS was unable to obtain written sampling procedures from the current laboratory. For this review, it is assumed that these procedures were followed. Even though duplicate samples were taken, it is not apparent that these data were used anytime during the ten years of post reclamation monitoring to check on the accuracy of the lab. In addition, cation-anion balance calculations apparently, were not performed. The cation-anion balance is a long-practiced, standard procedure to check analytical data where relatively complete mineral analyses are available, which is true in this case. To calculate cation-anion balance, parameters for cations and anions are converted to meq/L and the sum of the major cations (Dissolved Calcium, Magnesium, Potassium and Sodium) should be within 5% of the sum of major anions (Total Alkalinity, Chloride, and Sulfate) in meq/L. In the case of the Post Reclamation monitoring only 42% of the samples were in the acceptable range (within 5% of each other), 33% fell within suspect range (within 5 to10% of each other) and 25% fell into the unacceptable range (greater than 10 % of each other). Every sampling period had at least one unacceptable sample. Had the data been reviewed and this simple calculation been made in a timely fashion, the laboratories could have been challenged. With only 42 % acceptable – we question the validity of the entire data sets.

- ***Data Review***

➢ Hydrochemistry - Groundwater

EVOLUTION with RETENTION TIME	
CATION	ANION
Calcium	Bicarbonate
↓	↓
Magnesium	Sulfate
↓	↓
Sodium	Chloride

Hydro Geo Chem, Inc. did a complete evaluation the hydrochemistry of the Jackpile-Paguate Mine. (Hydro Geo Chem, Inc. "*Effects of Uranium Mine Dewatering on the Water Resources of the Pueblo of Laguna, New Mexico, Final Report*", March 15, 1982) In their work, they concluded that groundwater at the mine site shows a chemical evolution from a calcium-sulfate to a sodium sulfate type. This is attributed to cation exchange along the groundwater flow path from the Zuni Uplift to the Pueblo area. When the water enters the Rio Puerco Fault Zone it mixes with more saline waters upwelling from the Permian rocks. Harold H. Zehner also evaluated groundwater at the mine site (Zehner, Harold H., US Geological Survey, Water Resources Investigation Report 85-4226, "*Hydrology and Water-Quality Monitoring Considerations, Jackpile Uranium Mine, Northwestern New Mexico*", 1985). His analysis indicated that well water in direct contact with clay and shale are dominated by sodium cations and bicarbonate/sulfate anions, whereas water from wells completed in more oxidized clay and shale are predominated by sodium – sulfate waters. Wells at the time of the Zehner (1985) study ranged in total dissolved solids between 900 and 1,500 mg/L.

Evaluation of groundwater water quality data from the 2005 sampling (the last full set of data at the site available at the preparation of the report) indicates that groundwater has evolved over time with sulfate in most cases being the predominate anion and sodium being the predominate cation in pit wells and in wells which are completed in the Jackpile Sandstone. Wells completed in the alluvium range from calcium-sulfate type water (MW-4) and calcium-bicarbonate water (MW-3) in wells crossgradient to the mined pits to magnesium–sulfate water (MW-2 and MW-6) in wells downgradient of pits. These wells can be influenced by recharge from adjacent surface waters. These data are summarized in Table 28. Total dissolved solids (TDS) have increased from those reported in the earlier studies, ranging between 671 mg/L (MW-3) and 8,080 mg/L (NPOP20E).

Table 28
2005 Groundwater Quality (Major Cation and Anion) Summary

Well Number	Position	Total Dissolved Solids (mg/L)	Water Type	
			Predominant Cation	Predominant Anion
Jackpile Sandstone Formation Wells				
MW-1	Upgradient of NP Pit	719	Sodium	Sulfate
MW-7	Upgradient of Jackpile near large area of ponded surface water runoff	665.91	Sodium	Bicarbonate
MW-5	Downgradient of SP Pit	1359	Sodium	Sulfate
Alluvium				
MW-2	Downgradient of Jackpile Pit Adjacent Rio Moquino	3200	Magnesium	Sulfate
MW-3	Crossgradient of NP Pit Adjacent Rio Paguate	671.05	Calcium	Bicarbonate
MW-4	Crossgradient of SP Pit Adjacent Rio Paguate	1069	Calcium	Sulfate
MW-6	Downgradient of all pits Adjacent Rio Moquino near South Boundary	2460	Magnesium	Sulfate
Assumed Fill Material – both Protore and waste rock				
NPOP20E	Within NP Pit	5360.5	Sodium	Sulfate
NPOP20W	Within NP Pit	8080	Magnesium	Sulfate
SPOP-34	Within SP Pit	1329	Sodium	Sulfate
SPOP-35	Within SP Pit	2637	Sodium	Carbonate

Finally, trends in total dissolved solids in groundwater water samples are quite variable. While there appeared to be slight downward trends through 2005, the data obtained for 2006 and 2007 sampling events indicate the TDS values are returning to former levels.

➢ *Hydrochemistry - Surface Water*

Zehner (1985) concluded that the Rio Moquino contains greater concentrations of dissolved solids than does the Rio Paguate. The mean dissolve solids concentrations at the time of the Zehner study in the Rio Moquino range from 1,600 mg/L upstream from the mine area to 1,900 mg/L just upstream from its confluence with the Rio Paguate. In the Rio Paguate the total dissolved solids increased to about 2,000 mg/L. The

Rio Moquino contained calcium, magnesium, and sodium concentrations in nearly equal proportions and sulfate concentrations greater than bicarbonate or chloride.

Again, looking at the last full set of data from 2005, there appears to be two types of water. Water samples from the Rio Paguate upstream from the mine (URP) and above the confluence (LRP) are calcium-magnesium-bicarbonate waters. Water samples from the Rio Moquino (URM, LRM) and at sampling stations on Rio Paguate below the confluence (PM) and at Ford Crossing (RT) are slightly more sodium rich with sulfate being the predominate anion. So the water is becoming more sodium-sulfate rich as it flows through the mine site.

- ***Contaminants***

One of the major concerns of the Record of Decision is the potential for contamination of surface water and groundwater, due to the mining and reclamation operations, to affect human health and post-reclamation land use opportunities. There were no contaminants of concern (COC) or limits set out in the ROD or FEIS. Therefore, it is difficult to determine compliance or not. OAS compared the data to available standards: Primary and Secondary Drinking Water Standards and Agricultural Standards.

Primary drinking water regulations (CFR Title 40 – "*Protection of Environment, Chapter 1 – Environmental Protection Agency, Part 141 – National Primary Drinking Water Regulations*"); and related regulations are applicable to public water systems. Secondary drinking water regulations (CFR Title 40 – "*Protection of Environment, Chapter 1 – Environmental Protection Agency, Part 143 – National Secondary Drinking Water Regulations*") control contaminants in drinking water that are non-health related, but intended to protect the public welfare. These regulations are not directly applicable to this situation, but are intended as guidelines.

<u>Primary Drinking Water Regulations</u> (Maximum Contaminant Limits)

- Fluoride – Concentrations exceeding 4 mg/L were found in all samples taken from MW-1, an upgradient well
- Lead – One excursion of the standard of 0.015 mg/L was found in MW-1
- Arsenic – One sample from MW-4 exceeded the standard of 0.01 mg/L.
- Gross Alpha – All surface waters, groundwater, and pit wells had exceedances of the Gross Alpha MCL except for the reservoir. Many had exceedances for each sampling period.

Table 4-1
Gross Alpha Exceedances of the 15 pCi/L MCL

Location	# samples > 15 pCi/L	Range	
Groundwater			
MW-1	1 of 9	ND	17.33
MW-2	10 of 10	12.51	97.67
MW-3	6 of 9	31.92	104.85
MW-4	9 of 9	20.99	202.3
MW-5	3 of 9	ND	23.94
MW-6	9 of 9	ND	118.72
MW-7	4 of 9	9.11	40.63
Surface Water			
NP Pond	1 of 1	1468.05	
Railroad Tresel	10 of 10	37.59	214.33
Lower Rio M	7 of 10	16.62	53.05
Lower Rio P	6 of 10	2.24	106.22
P-M Confluence	8 of 10	11.19	94.03
Upper Rio M	2 of 10	ND	35.11
Upper Rio P	1 of 10	ND	25.53
Paguate Lake	0 of 6	ND	3.04
Pit Wells			
NP-OP- 20 W	10 of 10	159.25	707.71
NP-OP- 20 E	10 of 10	8965.97	67,278.82
JP-OP- 41 N	1 of 1	385.07	
JP-OP- 41 S	1 of 1	323,803.05	
SP-OP-34	10 of 10	74.09	1490.91
SP-OP-35	10 of 10	1022	7385.57

- Uranium – All Surface waters, groundwaters, and pit wells had exceedances of the total uranium. Many had exceedances for each sampling period. The Lake/Reservoir is a public recreation area used for fishing.

Table 4-2
Total Uranium Exceedances of the 0.03 mg/L MCL

Location	# samples > 0.03 mg/L	Range	
Groundwater			
MW-1	6 of 9	3.87	6.27

Table 29
Gross Alpha Exceedances of the MCL = 15 pCi/L

Location	# samples > 15 pCi/L	Range	
Groundwater			
MW-1	1 of 9	ND	17.33
MW-2	10 of 10	12.51	97.67
MW-3	6 of 9	31.92	104.85
MW-4	9 of 9	20.99	202.3
MW-5	3 of 9	ND	23.94
MW-6	9 of 9	ND	118.72
MW-7	4 of 9	9.11	40.63
Surface Water			
NP Pond	1 of 1	1468.05	
Railroad Tresel	10 of 10	37.59	214.33
Lower Rio M	7 of 10	16.62	53.05
Lower Rio P	6 of 10	2.24	106.22
P-M Confluence	8 of 10	11.19	94.03
Upper Rio M	2 of 10	ND	35.11
Upper Rio P	1 of 10	ND	25.53
Lake/Reservoir	0 of 6	ND	3.04
Pit Wells			
NP-OP- 20 W	10 of 10	159.25	707.71
NP-OP- 20 E	10 of 10	8965.97	67,278.82
JP-OP- 41 N	1 of 1	385.07	
JP-OP- 41 S	1 of 1	323,803.05	
SP-OP-34	10 of 10	74.09	1490.91
SP-OP-35	10 of 10	1022	7385.57

- Uranium – All Surface waters, groundwater, and pit wells had exceedances of the total Uranium. Many had exceedances for each sampling period. The Lake is a public recreation area used for fishing.

Table 30
Total Uranium Exceedances of the MCL = 0.03 mg/L

Location	# samples > 0.03 mg/L	Range	
Groundwater			
MW-1	6 of 9	3.87	6.27
MW-2	10 of 10	0.07	299.32
MW-3	9 of 9	0.04	419.37
MW-4	9 of 9	0.09	624.51
MW-5	5 of 9	0.0002	11.76
MW-6	9 of 9	0.07	69.76

Location	# samples > 0.03 mg/L	Range	
MW-7	6 of 9	0.002	30.68
Surface Water			
NP Pond	1 of 1	3043.65	
Railroad Tresel	10 of 10	0.08	544.14
Lower Rio M	10 of 10	0.04	234.95
Lower Rio P	9 of 10	0.03	163.23
P-M Confluence	9 of 10	0.029	577.20
Upper Rio M	6 of 10	0.008	52.89
Upper Rio P	6 of 10	0.002	32.21
Lake/Reservoir	3 of 6	0.002	76.93
Pit Wells			
NP-OP- 20 W	10 of 10	0.86	7,928.19
NP-OP- 20 E	10 of 10	23.12	104,501.62
JP-OP- 41 N	1 of 1	10,832.15	
JP-OP- 41 S	1 of 1	427,233.06	
SP-OP-34	9 of 9	0.15	1021.27
SP-OP-35	9 of 9	5.12	20,538.10

- Radium 226 – Fewer samples exceeded the standard of 5 pCi/L. No surface water samples were above the standard. Groundwater wells exceeding the standard included (number of times exceeded are in parentheses): MW-1 (1), MW-6 (1) and MW-7 (4). All pit wells completed in fill material exceeded MCL in ***ALL*** sampling events except for NPOP20W and JPOP41N with the highest value of 384.89 pCi/l in JPOP41S.

Secondary Drinking Water Regulations

- Total Dissolved Solids – nearly all samples, both surface and groundwater, exceed the secondary standard of 500 mg/L
- Sulfate –most surface water and groundwater exceed the secondary standard of 250 mg/L
- Manganese – Several exceedances of the secondary standard of 0.05 mg/L during the 10 year monitoring period for both surface water and groundwater. These included (number of times exceeded are in parentheses) : MW-2 (10), MW-3 (3), MW-6 (7), SPOP35 (6), NPOP20W (10), NPOP20E (10), RT (2), LRM (5), LRP (6), PM (7), AND URP (8).
- pH – Two samples were in non-compliant, one from URM and the other from SPOP34.

➢ ***Agriculture***

Another concern of the ROD is the potential for the build up of salts in the bottom of the pits. Examination of the electric conductivity (EC) and TDS data indicates that all samples taken (in and out of the pits) present a high to very high salinity hazard for irrigation water as presented in Table29. Due to salinity alone, the groundwater is unsuitable for irrigation and stock watering.

Table 31
Salinity Hazard (USDA)

	Conductivity (μmhos/cm)	Dissolved solids (mg/L)
Low salinity, no detrimental effects expected	<250	<200
Medium salinity, detrimental effects to sensitive crops	250 – 750	200 – 500
High salinity, adverse effects on many crops	750 – 2250	500 – 1500
Very high salinity, suitable only for salt tolerant plants	2250 – 5000	1500 – 3000

Conclusions - Based on this review it is concluded that the intent of the ROD was met for water quality sampling, but there are some rather large data gaps. Conclusions cannot be drawn as to environmental impacts and long term health risks associated with water quality at the closed mine. The results of the radiological analyses of the monitoring well, surface water and particularly the pit wells, indicated inconsistencies in the data which should be resolved. The results of some of the pit well samples indicate levels that need to be evaluated and confirmed as soon as possible.

The four data gaps 1) the depth to water measurements were reportedly recorded in order to calculate the volume of water to be purged prior to sampling of the wells, but the record of those depths was incomplete, 2) the Jackpile pit wells were not installed until 2007, 3) the ponded water was not sampled and analyzed until 2007 (ponds were not anticipated during reclamation; they appeared in the latter half of the reclamation monitoring), and 4) a downgradient boundary well in the Jackpile Sandstone was not installed (the Jackpile Sandstone is reportedly not present at the boundary), collectively represent a major deviation from the ROD and is therefore, ***non-compliant***.

Recommendations - Based on these observations, the following recommendations can be made:

1. Continue sampling Jackpile pit wells, and install a discretionary well(s).
2. Install a discretionary well near the downgradient boundary. The location(s) of any discretionary well(s) should be selected in order to assess downgradient groundwater conditions. Two areas that could be considered

for this purpose are 1) upgradient from the Rio San Jose and 2) at the Mesita Dam. The downgradient monitoring wells(s) should be constructed so that the screened interval allows for both environmental compliance monitoring, as well as water table elevation measurements. The existing monitoring wells MW-5 and MW-6 were apparently screened in the bottom 10 feet for water level measurement purposes only

3. Continue sampling ponded water within pits.
4. Sample the ponded water at the north end of the site outside the Jackpile pit at least one more time. This pond extends onto the trust lands to the north where domestic cattle graze. The pond causes waste piles to be saturated and could lead to the release of contaminants from the waste pile.
5. Monitoring should continue for all the wells and surface waters until a risk assessment has been completed. Continued monitoring of surface water may be necessary to protect fowl and animals. Parameters which should be monitored include field parameters, major cations and anions, manganese, total dissolved solids, arsenic, fluoride, lead, gross alpha, radium 226, uranium (total), gross beta and Po-210. At that time sample locations can be further evaluated to determine if the monitoring can be further limited.
6. Water usage should be prohibited pending the results of additional sampling activities, QA/QC of previous lab results and the findings of the proposed Risk Assessment.
7. With the completion of sampling, data should be evaluated as to its accuracy. The laboratories should be required to perform cation-anion balances and if not within acceptable ranges, the samples should be redone.
8. A Quality Control/Quality Assurance analysis of all general chemistry, chemical and radiological reports and results needs to be conducted to evaluate the sampling procedures and analytical results. This should be followed by re-sampling of the water.
9. A risk assessment should be performed to determine the potential hazards and risks of the high levels of gross alpha, radium 226, and uranium in most samples, especially in wells in fill material and areas of public access. A risk assessment is needed prior to Resource and Land Use planning for the mine site.
10. With both surface water and groundwater samples showing some level of contamination, an evaluation should be made to determine if any contaminants have migrated beyond the compliance boundary. A compliance boundary must first be established.

- ***Subsidence***

Subsidence was of concern because of underground mining (P-7/10 Mine and PW-2/3 Mine) under sections of old highway 279. The predicted rate of subsidence is very low, but it was deemed prudent to monitor subsidence ***if and when*** the new highway 279 was temporarily closed for reclamation activities and the public was ***required*** to use the old road.